Instructions

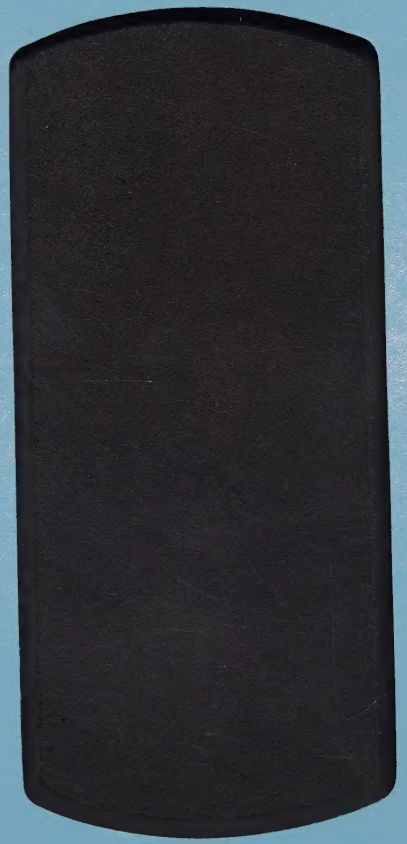
LOCAL-CONTROL CLOSED CIRCUIT
TELEVISION CAMERA

MODELS
4TE20A1, REVISION A
4TE20A2

EBI-6136A

MP MASTER
MA32573

GENERAL ELECTRIC



INSTRUCTIONS

LOCAL-CONTROL CLOSED CIRCUIT TELEVISION CAMERA

MODELS
4TE20A1, REVISION A
4TE20A2

EBI-6136A

VISUAL COMMUNICATION PRODUCTS DEPARTMENT
CONSUMER ELECTRONICS DIVISION

GENERAL ELECTRIC

ELECTRONICS PARK, SYRACUSE, N. Y.

4/69 (600)

PRINTED IN U.S.A.

CONTENTS

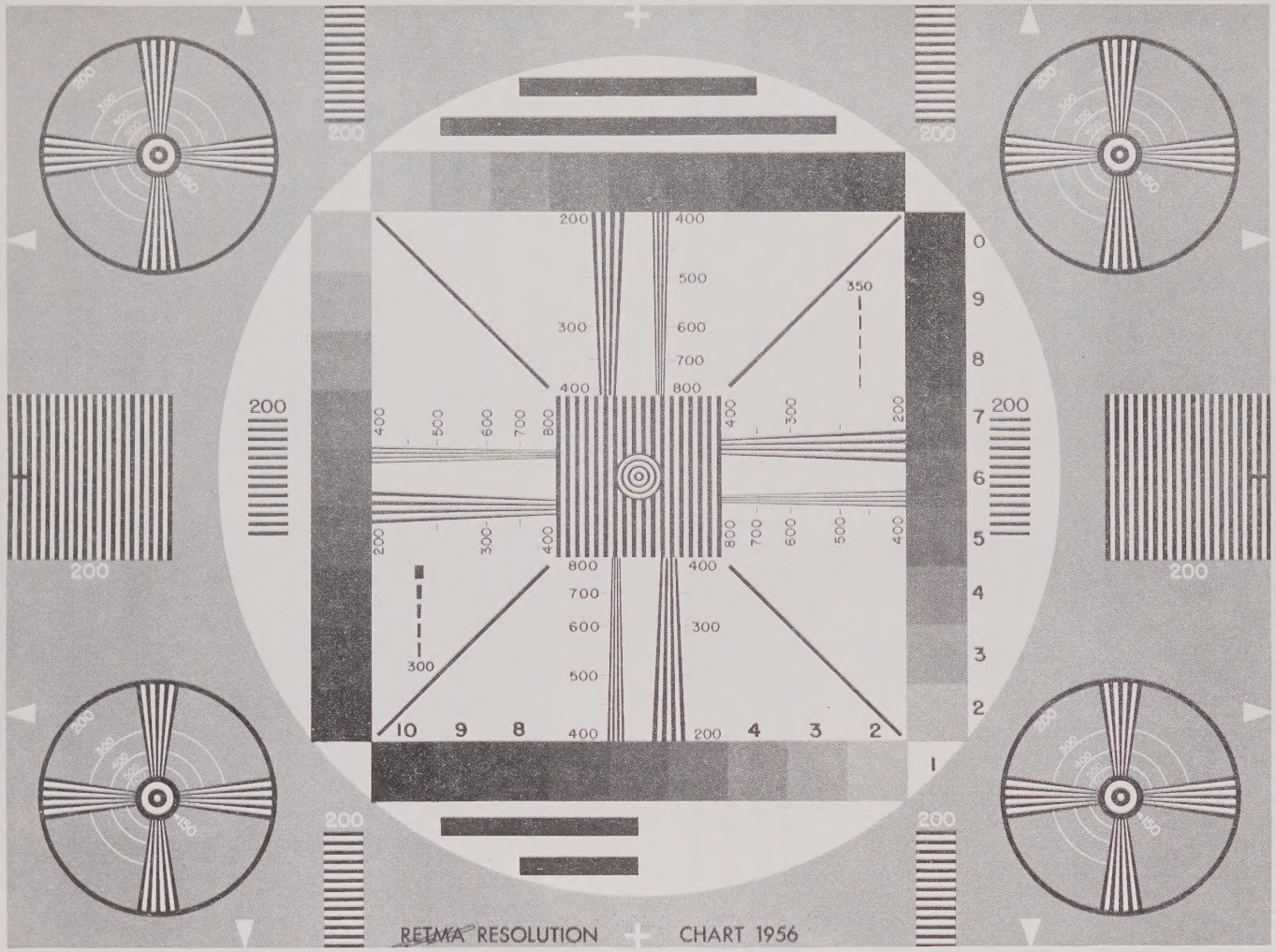
	Page
Introduction	1
Equipment	1
Accessories	1
Technical Summary	1
Description	2
Installation	3
Operation	6
Theory and Circuit Analysis	8
Maintenance	12
Parts List	17

ILLUSTRATIONS

Fig. 1 Camera Outline Diagram (C-7781821)
Fig. 2 2Q1 Emitter Waveform
Fig. 3 Response of Input Coupling Circuit
Fig. 4 High Peaker Signal Output
Fig. 5 Power Supply/Sweep Board Waveforms (a-h)
Fig. 6 Power Supply/Sweep Board Waveforms (i-m)
Fig. 7 Video Board Waveforms (a-f)
Fig. 8 Photocathode Image on Monitor Screen
Fig. 9 Equipment and Setup for Frequency Response Alignment (B-7497294, Sheet 1)
Fig. 10 Model 4TE20A1 Accessory Crystal Oscillator Module Component Location Diagram (B-7499749)
Fig. 11 Model 4TE20A1 Accessory Crystal Oscillator Module Schematic Diagram (B-7499750)
Fig. 12 Model 4TE20A2 Crystal Oscillator Board Component Location Diagram (C-7799576)
Fig. 13 Model 4TE20A2 Crystal Oscillator Board Schematic Diagram (C-7799577)
Fig. 14 Power Supply/Sweep Board Component Location Diagram (D-7673874, Sheet 1)
Fig. 15 Power Supply/Sweep Board Schematic Diagram (DD-7673874, Sheet 2)
Fig. 16 Video Board Component Location Diagram (D-7673873, Sheet 1)
Fig. 17 Video Board Schematic Diagram (DD-7673873, Sheet 2)
Fig. 18 Camera Schematic Diagram (D-7673875)

INSERTS

EBI-3711 Fundamentals of Television and Essentials of Optics
EBI-3781 Fundamentals of the Vidicon Tube and Transistor Characteristics
Vidicon Tube Bulletin
RETMA (EIA) Resolution Chart



RETMA Resolution Chart

INTRODUCTION

The General Electric Local-Control CCTV Camera, Models 4TE20A1, 2, designed as a high-quality Camera, produces a composite video television output signal of 1.0 volt peak-to-peak which can be displayed on any standard television monitor.

Models 4TE20A1 and 4TE20A2 are similar, except that Model 4TE20A2 includes a Crystal Oscillator Board, PL-7799576G1, as an integral part of the Camera. An accessory Crystal Oscillator Module is available for the 4TE20A1 on separate order (see ACCESSORIES, below).

EQUIPMENT

The Camera is completely self-contained and comes equipped with a three-conductor grounding type plug and line cord. If so ordered, the Model 4TE20A1 Camera will be shipped with the accessory Sync Board installed and tested at the factory.

A UHF plug (PL-259) and RG-11/U cable or RG-59/U cable (with the UG-176/U Adapter) is required for connection to the monitor. The Camera accommodates any C-mount (1"-32) vidicon format lens.

ACCESSORIES

The following accessories are available on separate order:

1. Sync Generator Module, PL-7673939G1, for positive 2:1 interlace (for use with the Model 4TE20A1 Camera only). Supplied are the Sync Board, PL-7673917G1, and the materials required for field installation of the Module. Applicable instruction book: EBI-6138. When discussed in this book, it is referred to as the Sync Board accessory.

2. Crystal Oscillator Module, PL-7499748 G1, 2, which provides a stable horizontal frequency and results in a nearly interlaced picture, PL-7499748G1 is provided with a 15.75-kHz crystal for 525-line operation, and PL-7499748G2 with a 20.25-kHz crystal for 675-line operation. Applicable instruction book: EBI-6195. This accessory, designed for use with the Model 4TE20A1 Camera only, is also discussed in this book.

3. Alignicon, PL-7782048G1, designed for use in aligning the preamplifier and video amplifier of General Electric CCTV Cameras. Applicable instruction book: EBI-6180.

TECHNICAL SUMMARY

Electrical

POWER INPUT

110/117/125 volts ± 10%, 50/60 hertz, at 20 watts.

INTERNAL POWER SUPPLIES

-20 volts regulated
+18 volts regulated
+190 volts
+300 volts regulated

-120 volts regulated
6.3 volts a-c and d-c
-26 volts
+26 volts
-21.5 volts
22 volts a-c
160 volts a-c

SIGNAL OUTPUT

1.0 volt composite into 75 ohms.

PERFORMANCE

High-Frequency Response: 8 megahertz ± 1 db.
Geometric Distortion: ± 2% or better.
Center Resolution: 650 lines.
Corner Resolution: 450 lines.

SCANNING STANDARDS

525 lines random interlace. (Accessory Sync Board provides two fields per frame, interlaced.)

Field Rate: 60 Hz.

OPERATING CONDITIONS

O C (32 F) to +50 C (122 F). (All performance specifications hold over this range.)

Conducted heat near the Camera must not be excessive. Radiated heat from an external source must not be excessive.

Vibration Specifications: 5 to 55 cycles with an excursion of 0.035 inch; 5 to 1000 cycles at 5_g under non-operating conditions.

Shock Specifications: 30_g in all planes.

Mechanical

CAMERA (Exclusive of Lens)

Length:	11-3/4 inches
Diameter:	$5\frac{1}{2}$ inches
Weight:	10 pounds

DESCRIPTION

General

The basic Camera is cylindrical in shape, 11-3/4 inches in length, $5\frac{1}{2}$ inches diameter, and consists of a frame assembly, rear panel, base casting, yoke assembly, and component boards. Refer to the Camera Outline Diagram, Fig. 1. Each of the component boards is secured to the Camera frame assembly with captive screws.

The tube-slide assembly is constructed of thick aluminum which, utilizing stainless steel ball bearings, provides a precision slide. The vidicon deflection assembly is fastened to the slide assembly and is adjusted (for mechanical focus) by a lead screw from the rear of the Camera.

Power Supply/Sweep Board

The Power Supply/Sweep Board consists of a resonant stabilized blocking oscillator circuit (Model 4TE20A1 only) that functions as the master oscillator when a sync generator is not used. This oscillator drives the horizontal sweep output through a buffer stage. In the Model 4TE20A2 Camera, this circuit is deleted, its function being assumed by the Crystal Oscillator Board.

For the vertical sweep, a 60-cycle sine wave from the power transformer high a-c winding is applied to the 15-volt zener diode. The saw generator is direct-coupled to the vertical output stage. Feedback is used to linearize the waveform. Four transistors are used in the blanking and sweep-failure circuits.

Video Board

The Video Board has a Nuvistor tube preamplifier followed by the high peaker circuit, a video gain control, and a feedback pair. This circuit is followed by a simple keyed clamp and the feedback video output

stage. The clamp pulse is about the same width as the blanking, and, because of the very low impedance of the clamp, most of the noise during blanking is removed.

The Video Board circuits also include a sync adder, sync delay line (for front porch), a one-transistor focus current regulator, and the +190 volt rectifier.

Crystal Oscillator Board

The Model 4TE20A2 Camera includes the Crystal Oscillator Board, PL-7799576G1, which establishes the H frequency (in the 4TE20A1 provided by the resonant stabilized blocking oscillator on the Power Supply/ Sweep Board).

INSTALLATION

Unpack the Camera from its carton and mount it on a tripod, or other mounting, with the $\frac{1}{4}$-20 inch mounting screw. Use one of the three tapped $\frac{1}{4}$-20 inch holes in the base of the Camera. Depending on the type of lens and accessories, use the hole that gives the best balance.

CAUTION

DO NOT USE $\frac{1}{4}$-20 SCREWS LONG ENOUGH TO EXTEND UP INTO THE FOCUS COIL ASSEMBLY SINCE DAMAGE MAY RESULT.

The Camera is shipped with the vidicon tube installed. Clean the face of the tube with a lens tissue before the Camera lens is installed.

Electrical Connections

For operation of the Camera, insert the line cord plug into a three-conductor grounding type a-c outlet delivering a nominal 117-volts, 60-hertz a-c.

Connect the video output jack to the display monitor. Proper operation of the Camera requires termination of the video output signal in 75 ohms at the last display monitor.

Camera Conversion to Positive 2:1 Interlace (with Accessory Sync Board)

The following application of the accessory Sync Board, PL-7673917G1, is relevant to the Model 4TE20A1 Camera only.

CAUTION

Unplug the power cord before removing the Camera cover and proceeding with the installation of the Sync Board.

SYNC BOARD INSTALLATION

The cover is removed by loosening the two screws at the rear plate and sliding it off the rear of the Camera. Drilling is provided in the top of the H-frame for mounting the Sync Board. All of the interconnections are made by the wires in the Sync Board pigtail to Keystone terminals provided on the Power Supply/Sweep Board. Refer to the interconnection details on the Camera Schematic Diagram, Fig. 18, and the instructions for the Sync Board, EBI-6138, which includes the installation drawing, Fig. 1.

Run the pigtail carefully down through the hole in the frame in front of the rear plate and out the right side so that the wire ends are adjacent to the Power Supply/Sweep Board terminals. If necessary, loosen the six captive screws on the Power Supply/ Sweep Board and the screws holding the 2Q5 heat sink to the rear plate, and carefully lift the Board away from the frame to facilitate the wire run. Using the interconnection detail on Fig. 18, identify the interconnecting wires and make the connections as shown. The connection is made by sliding the tinned end of the wire through the eye and into the clip portion of the terminal.

CAUTION

If, for any reason, these wires need to be disconnected, lightly

spring open the terminal clip with a solder aid or small screwdriver when removing the wire to avoid the possibility of breakage.

POWER SUPPLY/SWEEP BOARD

To convert the Camera for Sync Board horizontal and vertical drives, move jumper B to A and jumper C to D, as shown on the Power Supply/Sweep Board Schematic Diagram, Fig. 15.

Using a 20,000 ohm-per-volt voltmeter at terminal 23 on the Power Supply/Sweep Board, plug in the Camera power cord and check the -20 volt supply. If necessary, readjust 2R23, the -20 V ADJust control on the Power Supply/Sweep Board, for exactly -20 volts.

WARNING

Voltages dangerous to life are exposed when power is applied to the Camera with the cover removed. Use caution to avoid accidental contact with these voltages.

Disconnect the power, replace the cover and reinstall the two screws which secure it at the back of the Camera.

Accessory Crystal Oscillator Module

When the Crystal Oscillator Module is installed at the factory, the Camera is completely tested and adjusted before shipment; the following instructions, therefore, serve mainly as an aid to maintenance.

FIELD INSTALLATION

WARNING

UNPLUG THE POWER CORD BEFORE REMOVING THE CAMERA COVER AND PROCEEDING WITH THE INSTALLATION OF THE MODULE.

1. Remove the cover by loosening the two screws at the rear plate and slide it off the rear of the Camera.

2. Fasten the Module to the top compartment, using the middle set of holes in the rails.

3. All of the interconnections are made by the wires from the Module to the following Keystone terminals on the Power Supply/Sweep Board:

Crystal Oscillator Terminal	Power Supply/Sweep Board Terminal
1 (-21.5V)	21
2 (H drive)	1
3 (Ground)	17

Run the wires carefully down through the hole in the frame in front of the rear plate and out the right side so that the wire ends are adjacent to the Power Supply/Sweep Board terminals. If necessary, loosen the six captive screws on the Power Supply/Sweep Board and the screws holding the 2Q5 heat sink to the rear plate and carefully lift the Board away from the plate to facilitate the wire run. Identify the interconnecting wires and make the connections listed above. The connection (solderless) is made by sliding the tinned end of the wire through the eye and into the slip portion of the Keystone terminal.

CAUTION

IF FOR ANY REASON THESE WIRES NEED TO BE DISCONNECTED, LIGHTLY SPRING OPEN THE TERMINAL CLIP WITH A SOLDERING AID OR SMALL SCREWDRIVER WHEN REMOVING THE WIRE TO AVOID THE POSSIBILITY OF BREAKAGE.

4. Move the jumper on the Power Supply/Sweep Board from C to D.

CAMERA ADJUSTMENT FOR 525-LINE OPERATION

After installation of the Crystal Oscillator Module, proceed to make the following adjustments for 525-line operation.

WARNING

VOLTAGES DANGEROUS TO HUMAN LIFE ARE EXPOSED WHEN POWER IS APPLIED TO THE CAMERA WITH THE COVER REMOVED. BE EXTREMELY CAUTIOUS TO AVOID ACCIDENTAL CONTACT WITH THESE VOLTAGES.

1. Short the crystal out with a short clip lead and readjust 2L1 for a master oscillator frequency of approximately 15.50 kHz, using a frequency counter at the collector of 2Q2 on the Power Supply/Sweep Board. Remove the short.
2. Retune the horizontal frequency coil on the monitor by turning it clockwise until the monitor raster is locked with the Camera raster.
3. Adjust the monitor raster for the standard 3 x 4 ratio, with all edges visible.
4. Disconnect the power, replace the cover, and reinstall the two screws that secure it at the back of the Camera.
5. Re-apply a-c power and slap on the Camera to make sure that there is no intermittent picture disturbance.

CAMERA CONVERSION AND ADJUSTMENT FOR 675-LINE OPERATION

After installation of the Crystal Oscillator Module, proceed to make the following conversion and adjustments for 675-line operation.

For conversion of the Camera to 675-line operation, the following components on the Power Supply/Sweep Board must be changed:

Symbol	Remove
2C4	Capacitor, mylar, dielectric; 0.1 mfd ± 5%, 50 v d-c w. GE Drawing B-7496934-P206.

Replace With

Capacitor, mylar, dielectric; 0.047 mfd ± 5%, 50 v d-c w. GE Drawing B-7496934-P204.

Symbol	Remove
2R35	Resistor, composition; 100 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing C-3R152-P101J.

Replace With

Resistor, composition; 10 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing C-3R152-P100J.

Refer to the MAINTENANCE section under Component Board Service Notes for making these replacements.

Proceed to make the following adjustment:

WARNING

VOLTAGES DANGEROUS TO HUMAN LIFE ARE EXPOSED WHEN POWER IS APPLIED TO THE CAMERA WITH THE COVER REMOVED. BE EXTREMELY CAUTIOUS TO AVOID ACCIDENTAL CONTACT WITH THESE VOLTAGES.

1. Short the crystal out with a short clip lead and readjust 2L1 for a frequency of approximately 20.00 kHz, using a frequency counter at the collector of 2Q2 on the Power Supply/Sweep Board. Remove the short.
2. Readjust the H SIZE control on the Power Supply/Sweep Board.
3. Retune the horizontal frequency coil on the monitor by turning it clockwise until the monitor raster is locked with the Camera raster.
4. Adjust the monitor raster for the standard 3 x 4 ratio, with all edges visible.
5. Disconnect the power, replace the cover, and reinstall the two screws that secure it at the back of the Camera.
6. Re-apply a-c power and slap on the Camera to make sure that there is no intermittent picture disturbance.

OPERATION

Initial Operation

The procedure outlined below is recommended for initial operation of the Camera. It is assumed that the electrical connections are correct, the Camera is plugged in, the BEAM-ON switch is off, and a lens is in place. (Set the lens to f1.9 to f3.5 for normal scenes indoors, or f5.6 to f8 for normal scenes outdoors.)

CAUTION

NEVER ALLOW AN IMAGE OF THE SUN TO BE FOCUSED ON THE PHOTO-CONDUCTIVE LAYER OF THE VIDICON AT ANY TIME. DO NOT UNDER ANY CIRCUMSTANCE AIM THE CAMERA AT THE SUN WITH POWER ON OR OFF.

1. Apply power to the Camera by turning the BEAM control clockwise until a click is heard. Set the TARGET switch to MANual and adjust the TARGET control to the mid-range position. Allow three minutes for the vidicon and preamplifier to warm up.
2. Turn the BEAM control clockwise until a picture appears on the monitor.
3. Set the lens focus ring to infinity and optically focus the picture on the monitor by setting the screwdriver focus adjustment at the rear of the Camera.
4. Set the f stop on the lens used to the lowest value consistent with the depth of field required and the light available.
5. Set the TARGET control to obtain a 1.0-volt composite output.
6. Readjust the BEAM control, if necessary, to a point just above beam starving. As a rule, if the TARGET control setting is changed, the BEAM control will require readjustment.
7. Increase the video gain by adjusting 3R21 (located inside the Camera on the Video Board) if the scene illumination is very low. Normally, leave the GAIN control set at the 12 o'clock position.
8. Set the monitor CONTRAST and BRIGHTNESS controls for the most pleasing picture.

Automatic Target Adjustment

Adjust the TARGET control, if necessary, to the point that allows satisfactory operation over the scene brightness range to be encountered. This setting must be determined experimentally. With the Camera aimed at the darkest scene to be viewed, adjust the TARGET control until a quality picture is obtained. If a quality picture cannot be obtained with the lens iris wide open and the TARGET control set in the maximum clockwise position, more light is required. In general, if the video amplitude holds within a 2 to 1 range throughout the light range, the TARGET setting is correct.

Routine Operation

Whenever the Camera is placed in operation, allow for a three-minute warm-up period. This permits the heaters to become stabilized.

Once the preliminary adjustments have been made, routine operation of the Camera becomes very much simplified. Unless it is obvious that the Camera sweep controls are out of adjustment, do not change their settings. If adjustments must be made, perform them only according to the procedure outlined in the MAINTENANCE section. Large changes in scene illumination may require resetting either the lens iris or TARGET control. The BEAM setting must be readjusted when the TARGET setting is changed when the target is on MANual control.

Control Functions

ACCESSORY SYNC BOARD (OPTIONAL)

(The use of the accessory Sync Board is limited to the Model 4TE20A1 Camera.)

The AFC jumper on the Sync Board must be in the ON clip for 60-cycle line lock operation. If non-line lock or 50-cycle operation is desired, the jumper must be moved to the OFF position.

The controls on the accessory Sync Board are set-up or maintenance type adjustments and they are set at the factory before ship-

ment. Since the control settings are critical to the proper operation of the Sync Board, no routine operating adjustment of these controls should be attempted. For additional information, see EBI-6138.

If the Camera does not seem to synchronize properly, readjust 2L1 on the Power Supply/Sweep Board (see below).

POWER SUPPLY/SWEEP BOARD

Control	Name	Function
2L1	Horizontal Frequency	In the Model 4TE20A1 only, sets the LC time constant in the emitter of 2Q1, and thereby sets the free-running frequency of the master oscillator to 15.75 kHz. If horizontal and vertical drives are used (optional Sync Board), 2L1 adjusts the 2Q1 circuit to lock with incoming horizontal drive.
2R11	H SIZE	Adjusts the horizontal sweep size by varying the amount of d-c voltage at the collector of the horizontal sweep transistor, 2Q3.
2R16	H CENT	Adjusts horizontal sweep centering.
2R23	-20 V ADJ	Adjusts the -20 volt regulator output to exactly -20 volts.
2R25	ALIGN 1	Adjusts the magnitude and polarity of the current fed to vidicon alignment coil 1.
2R30	ALIGN 2	Adjusts the magnitude and polarity of the current fed to vidicon alignment coil 2.
2R33	V SIZE	Adjusts the size of the vertical sweep by varying the time constant of the sawtooth generator.
2R36	V LIN	Adjusts the over-all vertical linearity by setting the amount of negative feedback in the vertical sweep generator.
2R44	V CENT	Adjusts vertical sweep centering.

VIDEO BOARD

3C12	High Peaker	Balances the high peaker time-constant to compensate for the preamplifier input time constant. While observing a test chart on the monitor, adjust for absence of black or white overshoot following a transition.
3R21	Gain	Sets the gain of the video amplifier. For normal operation, the setting should be one-half of full gain. Under extremely low light level conditions, this control can be set fully clockwise; however, noise, as well as signal, will be amplified at full gain.

CAUTION

Any changes in the settings of 3C9, 3C13, 3L2, 3R17, or 3C22 necessitate a time-consuming, complete realignment of the video amplifier with a sweep generator and probe.

THEORY AND CIRCUIT ANALYSIS

Vidicon Tube

Refer to the pertinent vidicon tube bulletin and to EBI-3781, Fundamentals of the Vidicon Tube and Transistor Characteristics, included as an insert in this book.

Power Supply/Sweep Board

Refer to the Power Supply/Sweep Board Schematic Diagram, Fig. 15.

The Power Supply/Sweep Board contains the circuits to generate vidicon horizontal and vertical sweep currents, clamp pulses for the Video Board, alignment coil currents, and the basic power supplies for the entire Camera.

POWER SUPPLIES

The Camera power transformer is mounted at the rear underneath the main Camera frame. The transformer has three windings which supply current for the filaments (vidicon and video preamplifier), the +190 volt supply (on the Video Board), and the -20 volt, +18 volt, and +26 volt supplies on the Power Supply/Sweep Board. The winding with the blue-yellow-blue leads supplies 44 volts a-c to the two sets of rectifiers, 2CR6-2CR7 and 2CR8-2CR9, on the Power Supply/Sweep Board. Each set acts in a full-wave center-tapped rectifier circuit, one set supplying -26 volts, the other +26. The filter capacitors, C3 and C4 (in the Camera frame) and 2C16 (on the Power Supply/Sweep Board), provide smoothed d-c.

The -26 volt output is applied to the series regulator transistor, 2Q5, which acts with 2Q11 in a standard solid-state voltage regulator circuit. A resistance divider between the -20 volt regulated output and ground is formed by 2R22, 2R23, and 2R24. A sample of current proportional to the output voltage is applied from 2R23 to the base of the d-c amplifier, 2Q11. Any current variations at this point caused by changes at the -20 volt output are amplified and applied to the base of 2Q5. The current in the base of 2Q5 is changed to correct the output voltage and hold it exactly at -20. 2Q11 compares the sampled current with the zener diode in its emitter, insuring a stable voltage output at the -20 volt bus.

The +26 volts from 2CR8 and 2CR9 provides current for horizontal and vertical centering and some current for the vertical sweep output transistor, 2Q7. In addition, some +26 volt current is dropped through 2R29 and regulated by the zener shunt regulator, 2CR11, to +18 volts. The latter is used throughout the Camera in various circuits.

Some current from the -20 volt supply zener diode reference element is bled off through the alignment coils and the alignment adjustment potentiometers, 2R25 and 2R30. The circuit is arranged to provide alignment currents of either polarity in varying amplitude, providing for exact magnetic beam alignment of the vidicon tube.

HORIZONTAL SWEEP

Reference to the blocking oscillator circuit in the following applies to the Model 4TE20A1 Camera only; establishment of the H frequency in the Model 4TE20A2 is discussed under Crystal Oscillator Board, page 10.

Without the Sync Board, the TE-20-A Camera operates with non-interlaced fields, thus needing no lock between the horizontal and vertical sweeps. Accordingly, the horizontal sweep generator begins with a free-running oscillator at a frequency of 15.75 kilohertz. The master oscillator, 2Q1, is a resonant-stabilized blocking oscillator. The combina-

tion of RC and LC in its emitter circuit results in an emitter waveform of the type shown in Fig. 2. The type of wave illustrated is desirable because the pulse increases most rapidly near the top at the point where the blocking oscillator is fired. This results in a more stable circuit than if an ordinary sawtooth were formed at the 2Q1 emitter. When the accessory Sync Board is used, the blocking oscillator is triggered by horizontal drive from the Sync Board. In this mode of operation, it must be retuned to a slightly lower frequency (about 15.0 kHz) by 2L1.

Narrow horizontal pulses are fed from the output winding of the blocking oscillator transformer, 2T1-5, -6, to the base of the pulse amplifier-clipper-inverter, 2Q2. The output of 2Q2 is a positive-going horizontal rate pulse which is of the width determined by the circuit constants, notably 2C7. The positive pulse from 2Q2 is applied to the base of the horizontal sweep output transistor, 2Q3. If a step function of voltage is applied to a pure inductance, the current through the inductance increases linearly with time until the voltage is removed. If successive steps of voltage are applied to a pure inductance at a 15.75-kc rate, as in this case, a 15.75-kc sawtooth flows in the inductance. A transistor functions very well as a switch, that is, has a very low resistance when on and a very high resistance when off. 2Q3 acts as a switch in the horizontal sweep circuit to apply voltage steps to inductor 2L2. When 2Q3 is turned off rapidly by the positive pulse on its base, its collector current rings in 2L2, the first ring excursion being the step voltage applied to the horizontal deflection coil. Diode 2CR2 clips off and prevents any succeeding rings.

Since the horizontal deflection coil has some resistance, the sweep current would rise exponentially instead of linearly. To prevent this, the total Q of the circuit is increased by adding 2L3 in series with the horizontal deflection coil. Thus, the total inductance is almost doubled, but the resistance is increased by only a few percent. Horizontal sweep size is controlled by changing the d-c collector voltage of 2Q3 with the H SIZE control (2R11). 2C11 resonates with 2L2 and 2L3 plus the horizontal deflection coil to give a flyback pulse of eight or nine microseconds duration.

Horizontal centering current is obtained from a current divider between the -20 volt and the +18 volt buses and is shunt-fed to the deflection coil through 2L4 for a-c isolation. 2R14 limits the centering current to the correct maximum value of about ± 20 ma.

VERTICAL SWEEP

When used without the Sync Board (jumper B in place), a 60-cycle sine wave from the high a-c winding of power transformer T1 is fed through 2R60 and applied to the 15-volt zener diode, 2CR12. This diode clips out a 15-volt slice near the sine-wave axis. The slice is approximately a square wave, which is differentiated into a positive- and negative-going pulse by 2C17 and 2R31. 2CR13 clips off the positive pulse and d-c restores the wave to ground potential. The negative pulse remaining is applied to the base of 2Q6. When the accessory Sync Board is used (jumper A in place), negative vertical drive is fed to 2Q6.

The negative vertical trigger turns the discharge transistor, 2Q6, on to short out the sawtooth charging network which has been linearly rising toward -20 volts between pulses. The saw network is comprised of 2R38, 2R39, 2C21, 2C19, 2R34, and the V SIZE control, 2R33. The generated sawtooth is applied to the vertical sweep output stage, 2Q7, which, through 2C23, drives the vertical deflection coil. Note that 2R38 and 2R39 in the sawtooth charging network provide a pulse component in the vertical sawtooth wave which improves the top linearity of the Camera. Some sawtooth is fed from the sweep output stage emitter back to the sawtooth charging network through the Vertical LINearity control, 2R36, to improve and provide a positive adjustment of the sawtooth linearity.

Some vertical sawtooth with its pulse component is fed out to the Video Board for use in the sync adder stage.

Vertical centering current is obtained from a divider between -20 volts and +26 volts in a manner similar to that described for horizontal centering.

BLANKING ADDERS AND SWEEP FAILURE PROTECTION

A small amplitude of the horizontal sweep pulse is clipped by 2CR3 and fed to the horizontal amplifier, 2Q4, which feeds negative horizontal pulses to the base of the horizontal blanking adder, 2Q10. In addition, 2Q4 provides positive horizontal drive pulses from its collector, which are sent to the Video Board for use in the sync adder stage.

A small amplitude of the vertical sawtooth step or pulse component is clipped off and amplified by the vertical amplifier, 2Q8. Negative vertical pulses are applied to the base of the vertical blanking adder, 2Q9.

The blanking adder stages, 2Q9 and 2Q10, are both biased in such a way that in the absence of base drive pulses they turn on hard and connect the vidicon cathode to the +18 volt bus, blanking the vidicon off completely. Thus, if either the horizontal or vertical base drive pulses derived from the sweep circuits fails, the vidicon is blanked and protected against scanning burns. Therefore, 2Q9 and 2Q10 function as vidicon blanking adders and sweep failure protectors.

Crystal Oscillator Board (Model 4TE20A2 Only)

Refer to the Crystal Oscillator Board Schematic Diagram, Fig. 13.

The Crystal Oscillator Board, PL-7799576 G1, establishes the H frequency.

The Board contains both a crystal oscillator and a monostable multivibrator. The crystal is operated in a multivibrator-type circuit that produces a square-wave output. The monostable multivibrator triggers either from the sharp negative-going edge of the crystal output or from an optional negative-going external drive waveform.

The period of the multivibrator is fixed at 10 usec to turn off the horizontal switching transistor, 2Q3, on the Power Supply/Sweep Board.

Video Board

Refer to the Video Board Schematic Diagram, Fig. 17.

The Video Board contains the circuits to amplify the output signal of the vidicon tube and process it into a one-volt peak-to-peak composite video signal suitable for feeding one or more television monitors in a bridged-through manner. In addition, it contains a current regulator for the vidicon focus coil current and two higher voltage rectifier-filter circuits to provide -120 volts for the vidicon beam bias and +300 volts, zener diode regulated, for the vidicon grid 2 and 3 potentials.

VIDEO AMPLIFIER

The video amplifier is a one-tube, seven-transistor circuit, which amplifies the vidicon output video signal to a level of 0.7 volt peak-to-peak and feeds it out to a 75-ohm line.

In order to realize a better signal-to-noise ratio than can presently be obtained with a transistor preamplifier, a vacuum tube (Nuvistor) is used as the first stage. Although it has less than unity gain, being a cathode follower, it has high power gain and serves to match the high-impedance output of the vidicon tube to the low-impedance input of the first transistor, 3Q1. Vacuum tube microphonics are minimized, owing to the high value of the signal load resistor, 3Q3 (470,000 ohms). The vidicon has a constant-current output, and, as a result, the signal voltage throughout the audio-frequency range at the grid of 3V1 is quite high (about 0.07 volt). Above 20 kilohertz, however, the stray capacitances in the circuit start to cause a roll-off of the signal.

Fig. 3 shows how the signal at the vidicon output rolls off because of strays and the vidicon output capacitance. To remedy the situation, the signal is fed through the high peaker stage, 3Q1. The stage is made highly degenerative at the lower frequencies by use of the large emitter resistor, 3R16. As the frequencies rise, the effect of the bypass capacitors, 3C11 and 3C12, becomes appreciable, until at the RC crossover, the signal output of 3Q1 is rising so as to double every octave. 3C12 is a variable capacitor allowing the time constant of the 3Q1 emitter to be adjusted to exactly match the time constant of the vidicon output circuit. Fig. 4

also illustrates how the signal output of the high peaker is the exact complement of the signal output of the vidicon circuit. The resultant signal response, as shown, is flat.

A further improvement in the signal-to-noise ratio and sensitivity of the Camera is achieved through the pre-peaking network R8-L3 (refer to the Camera Schematic Diagram, Fig. 18). This RL circuit has the effect on the frequency response shown in Fig. 4. This must be considered while ignoring the roll-off and high peaking just described. The high frequencies are over-peaked ahead of the chief noise source, 3V1, and then are compensated back to flat by a complementary circuit in the base of 3Q2 (3C13, 3L2, and 3R17), an action that takes place after the noise source. The action described improves the signal-to-noise ratio of the Camera in a fashion similar to that of the system used in FM broadcasting, where the transmitted signal is pre-distorted (pre-emphasis), and the FM receivers are compensated to suit (de-emphasis).

The remainder of the video amplifier consists of two feedback pairs; the first contributing gain, the second a low output impedance to drive a 75-ohm line from a 75-ohm source.

The base of the output feedback pair is clamped by a keyed clamp, 3Q5. 3Q5 is fed mixed horizontal and vertical blanking pulses from the Power Supply/Sweep Board and establishes the bias of 3Q6 at about 0.0 volt. A characteristic of the clamp circuit used at 3Q5 is that during the clamped intervals, the base of 3Q6 is switched hard to ground through the saturation resistance of 3Q5, which is only a few tenths of an ohm. Owing to this, all random noise which would otherwise ride through the blanked period on the signal is shorted out.

SYNC ADDERS

The sync adders are transistor switches, switching between the regulated -20 volts and ground. Positive horizontal pulses and positive vertical sawtooth waves from the Power Supply/Sweep Board are fed to the bases of 3Q8 and 3Q9 to turn them on (pulse present) and off. Note that the positive horizontal pulse is fed through a delay line to add a front porch to the signal. 3Q9 clips the pulse component from the vertical sawtooth wave and produces vertical sync from it. The switched output of the adders is connected through the video output stage output network, and, when a 75-ohm termination resistor is connected at the output, a composite sync signal of 0.3 volt peak is added to the video signal.

FOCUS CURRENT REGULATOR

The focus current regulator, 3Q10, is a d-c current regulator to maintain the current through the vidicon focus coil at a constant value regardless of temperature changes which change the coil's resistance. A zener reference diode in the base circuit establishes the current flowing through 3Q10, and, therefore, that flowing in the coil, which is in the collector circuit. The transistor is an excellent constant-current generator and keeps the current to 40 ma within ± 1% over the temperature range of the Camera, 0 C (32 F) to +50 C (122 F).

HIGH-VOLTAGE RECTIFIERS

The 160 volts a-c is fed to the Video Board and rectified and filtered three times. Some is rectified by 3CR1 and filtered by 3C6 into the +66 volts d-c required by the preamplifier tube, 3V1.

Two 150-volt zener diode shunt regulators (3CR6 and 3CR7) control the output of a voltage doubler circuit, 3CR2-3CR3-3C33-3C34. The +300 volts d-c is fed to grids 2 and 3 of the vidicon tube. The voltage to grid 3 is controlled by the TARGET control potentiometer.

3CR4 and 3C36 rectify and filter the -120 volts d-c required by the BEAM control circuit for application to grid 1 of the vidicon tube.

TARGET CIRCUIT

Both a manual and an automatic target control circuit are provided in the Video Board. The AUTO-MAN switch (S2) on the rear of the Camera connects the selected circuit to its proper voltage source and makes it operational.

The vidicon signal current is a function of light and target voltage. A device which produces an equivalent decrease in target voltage with an increase in light results in a relatively constant signal output from the Camera. In the AUTOmatic TARGET mode of operation this is achieved in the target circuit of V1 by inserting a very large resistor (3R5, 1000 megohms) in series with the higher target voltage supply. As an increase in light produces an increase in signal current, the voltage drop across 3R5 is increased. This increased voltage drop across 3R5 causes the target voltage to drop until the signal current is again very near its original value and the Camera output remains relatively close to constant amplitude. This correction is made in less than 0.5 second. The MANual TARGET control circuit operates through lower resistances, with a lower voltage supply, and thus permits manual adjustment for light variations. The MANual position allows a greater range of light levels to be viewed with manual set-up required for each.

Characteristics of Semiconductors

Refer to EBI-3781, included as an insert in this book.

MAINTENANCE

General

To assure continuous satisfactory operation of the Camera, the first requirement is to keep it as clean and dry as possible. Always leave the cover on the Camera for best protection. Take care not to disturb the position of the components and wiring.

Parts Replacement

The Parts List for each chassis is located in the back of this book.

If a component requires replacement, obtain its description from the Parts List and the part from a local parts distributor. In cases where a special part not available from a distributor must be replaced, order it by GE Drawing number (found in the Parts List), addressing the order to the General Electric Company, Replacement Parts, Visual Communication Products Department, Electronics Park, Syracuse, New York.

Component Board Service Notes

The following steps will be of aid when replacing components on the component boards. Use only a 25- or 35-watt soldering iron to service the equipment as excessive heat can damage wiring and components.

CAUTION

DO NOT USE A LARGE SOLDERING IRON TO SERVICE THE BOARD.

DO NOT REMOVE A TRANSISTOR FROM ITS MOUNTING FACILITY WHILE POWER IS APPLIED TO THE PARTICULAR BOARD; TO DO SO MAY PERMANENTLY DAMAGE THE TRANSISTOR.

1. Grip the component to be removed at one end with long-nose pliers, then apply a narrow-tip soldering iron to the component lead, barely touching the board wiring. While the solder joint melts, lightly pull with the pliers until the lead can be pulled free of the board. Free the other lead in the same manner.
2. When a component is removed, it should be replaced with a new component of the same value. When installing the new component, observe the length and dress of the leads on the old component, then cut and bend the leads of the new component in the same way.
3. Place the leads in the holes. If residual solder prevents a lead from entering the hole, very gently ream out the solder with a sharply pointed, square awl. Then place the leads in the holes so that the component is held in place by friction or slight spring tension of the leads.
4. Using high grade electrical solder, ap-

ply the soldering iron tip, then apply the solder to the junction of the hole, so that a very small amount of solder flows around the lead and into the hole, bonding the lead to the board.

5. Examine the joint carefully. A good solder joint should withstand a light pull by the fingers. Clear away any loose solder, making sure that no scraps fall where they might cause a short.

Trouble Shooting

The first step in locating trouble is to isolate it to a particular section of the Camera. Socket voltages are included on the Schematic Diagrams and are useful in point-to-point checking.

A list of the more common difficulties and faults that may arise in the Camera are given below.

Trouble	Remedy
Low contrast picture without excessive noise (snow).	Advance the monitor CONTRAST control. Advance the TARGET control. Open the lens iris.
Low contrast picture with noise (snow).	Open the lens iris. Provide more scene illumination.
Lack of detail.	Focus the electrical FOCUS control. Focus optically. Clean the front of the vidicon tube and lens. Turn down the TARGET and monitor CONTRAST controls (picture was overloading monitor). Turn down the BEAM control.
Camera will not operate (pilot light does not light).	Check Camera 3/8 ampere fuse.
Pilot light lights but there is no picture output.	Check -20 V at 2Q5 emitter. Advance the BEAM control setting. Make certain V1 lights up and 3V1 is warm.
Picture will not lock horizontally.	Check master oscillator frequency. Check the coaxial cable from the video output to the monitor for open or short.
Picture blooms.	Make certain the video cable is terminated at the monitor in 75 ohms.

Although the circuit boards are designed to be extremely rugged when mounted as an integral part of the Camera, great care must be used in handling them when alone. Parts may be damaged, for example, by placing a board component-side down and inadvertently placing another object on the board.

CAUTION

IN ORDER TO INSURE PROPER CAMERA OPERATION, IT IS A MUST TO FIRMLY TIGHTEN ALL CAPTIVE BOARD MOUNTING SCREWS WHEN REPLACING A BOARD.

When replacing the Camera cover, slide it slowly forward, making certain no components are projecting from the board and that the cover is properly seated.

Trouble-Shooting Transistor Circuits

The trouble-shooting techniques described in EBI-3781 are applicable to this Camera.

Refer also to the waveforms, Figs. 5, 6, and 7.

Testing Transistors

Refer to EBI-3781.

Lenses

Exercise care when cleaning coated lenses since they are easily scratched. Use the following procedure for cleaning:

1. Slightly moisten a lens cleaning tissue, or other similar material, with isopropyl alcohol and wipe the lens, using a light pressure.
2. Use a soft camel hair brush when the lenses are subject to dust only. Tape the metal ferrule on the brush to prevent accidental scratching of the lens.

Camera and Sweep Chassis Adjustment

NOTE

Set the BEAM control fully counterclockwise and allow the Camera a 15-minute warm-up before attempting to adjust the sweep circuits.

1. Position the RETMA resolution chart, located in the back of this book, on a wall or other convenient support facing the Camera. The center of the chart must be at the height of the lens, and the chart should have the plus (+) sign at the top and the title at the bottom.
2. Reduce the H and V SIZE controls on the monitor until the entire monitor raster, including the corners, is visible.
3. Overscan the vidicon tube by turning the H and V SIZE controls on the Power Supply/Sweep Board counterclockwise until the complete circular image of the vidicon photoconductor is visible on the monitor screen.
4. Because some vidicons are now manufactured with the faceplate masked off to indicate the proper area to be scanned, the following steps will insure proper scan of the required $\frac{1}{2}$ x 3/8 inch area of the vidicon photoconductor.

Position the RETMA resolution chart in front of the Camera at the distance that corresponds to the lens being used. Refer to the Chart-To-Camera Distance Table, below. Adjust the sweep so that the entire chart is just displayed on the monitor. Disregard the black border around the chart. Refer to Fig. 8.

CHART-TO-CAMERA DISTANCE TABLE

Lens	Distance
15 mm	$10\frac{1}{2}$ inches
25 mm	16 inches
50 mm	33 inches
75 mm	$49\frac{1}{2}$ inches
100 mm	$65\frac{1}{2}$ inches

All measurements were taken from the chart to the bottom front edge of the Camera.

It may be necessary to reduce the TARGET voltage control setting so that the edge of the photoconductor is clearly defined. Do not move the chart or the Camera.

5. Adjust the height (V SIZE), vertical centering (V CENT), width (H SIZE), and horizontal centering (H CENT) controls on the Sweep Board so that the chart just fills the monitor raster. Note the small white wedge-shaped indicators on the edge of the chart. When these arrows touch the edges of the raster, the size and centering controls are properly set.
6. Expand the monitor presentation back to its normal size.
7. Adjust the vertical linearity control (V LIN) for the best vertical linearity.
8. Adjust the two ALIGNment potentiometers on the Power Supply/Sweep Board until, as the electrical FOCUS control is rocked through the focused point, the small circle at the center of the RETMA resolution chart appears to rotate about a fixed center point.

Frequency Response Alignment

To properly align the preamplifier of a high-gain vidicon video strip, it has been found necessary to employ a special sweep probe. Refer to Fig. 9 for a diagram of the sweep probe alignicon circuit. It is important

to note that the probe must be constructed so it will be completely shielded by metal, and all leads must be kept as short as feasible. The output lead should be as short as possible while allowing it to be connected to the vidicon target contact through the lens opening at the front of the Camera.

In addition to the sweep probe, a completely shielded detector probe, shown in Fig. 9, is required. It is recommended that the detector probe be constructed in a small aluminum or copper box or tube, with all components inside the box, and that UHF-type coaxial connectors be used for input and output terminals.

Follow the procedure below to align the frequency response of the video amplifier.

1. Remove the vidicon by the procedure in the following section.
2. Connect the test equipment to the Camera as shown in Fig. 9.
3. Remove 3Q5, 3Q8, and 3Q9 from the Video Board.
4. Insert a 2200-ohm, $\frac{1}{4}$-watt resistor with short leads between the collector and emitter of socket 3XQ5.
5. Apply Camera a-c power, set the video gain control, 3R21, to the 12 o'clock position, and observe the response on the 'scope. If no response is observed, check for connection between the alignicon and target contact.
6. The 'scope input sensitivity should remain at a high setting and the sweep generator output reduced to prevent overloading of the Camera amplifier.
7. Adjust 3C9, 3L2, 3R17, 3C13, and 3C22 for a flat frequency response to eight megahertz ± 1.0 db. 3C22 affects the over-all response. If necessary, interchange 3Q1, 3Q2, 3Q3, and 3Q4, to obtain flatter response. See Fig. 7(d) for a typical frequency response curve.
8. Remove the Camera a-c power and the alignment equipment.
9. Remove the 2200-ohm resistor from 3XQ5. Install 3Q5, 3Q8, and 3Q9.
10. Replace the vidicon by the procedure below.

Removing the Vidicon Tube

1. Disconnect all cables from the Camera.
2. Remove the Camera cover by loosening the two rear captive screw fasteners and carefully sliding the cover off.
3. Remove the lens.
4. Using the special spanner wrench supplied, unscrew the lens holder, using the two small holes in the holder to engage the wrench.
5. Run the vidicon/yoke assembly to its far forward position, using the focus screw at the rear of the Camera.
6. Loosen the C clamp on the vidicon socket retainer.
7. Unplug the vidicon socket, accessible underneath the rear of the Camera, from the vidicon.
8. Gently move the vidicon forward (from the rear) until about $\frac{1}{2}$ inch of the tube protrudes from the front of the Camera.
9. Carefully extract the vidicon from the front of the Camera.

Replacing the Vidicon Tube

In general, replacement of the vidicon is the reverse of the removal procedure.

1. Be sure to insert the vidicon so that its pins locate properly in the tube socket. The index (short) pin of the tube must line up with the tube socket hole with the screw in it.
2. Rotate the entire tube assembly until the index pin is in the 9 o'clock position when viewed from the front of the Camera. Tighten the C clamp to the socket retainer.

Power Supply Adjustment

Adjust the -20 volt potentiometer, 2R23, for a voltage of exactly -20 volts between ground and the emitter of 2Q5.

Circuit Board Removal

1. To remove the Power Supply/Sweep Board, first remove the screws in the Cam-

era rear plate holding the heat sink. Second, loosen all six captive screws. The Board will drop down for servicing.

2. To remove the Video Board, loosen the six captive screws and disconnect the target lead (near 3V1). The Board will drop down for servicing.

3. To gain access to the underside of the Crystal Oscillator Board, loosen the two captive screws that hold it in place.

4. When replacing the Boards, be sure to replace and tighten all screws. Loose mounting screws on the Video Board, for example, may result in video oscillation.

PARTS LIST

Symbol	Description	GE Drawing
	CAPACITORS	
C1	Ceramic, Hi-K disk; 0.01 mfd +100% -0%, 500 v d-c w.	C-7774750-P13
C2	Metallized mylar; 0.022 mfd ± 20%, 1000 v d-c w.	B-7493817-P11
C3	Electrolytic; 1500 mfd +250% -10%, 35 v d-c w. Illinois Condenser Cat. #SMT-50030.	C-7776308-P18
C4	Silver mica, epoxy dipped; 2200 mfd ± 5%, 500 v d-c w.	B-7496932-P16
	FUSE	
F1	Cartridge type; 3/8 amp at 250 v. Littelfuse Cat. #312.375, Bussman Cat. #AGC3/8.	K-1R16-P14
	INDICATOR LIGHTS	
I1	Neon, miniature, red lens. E-Lite Type #182, #5817.	A-4029824-P3
I2	Neon. GE Type NE2.	A-7164423-P1
	RECEPTACLE	
J1	Amphenol Cat. #83-1R, Signal Corps #SO-239.	M-2R22-P3
	INDUCTORS	
L1	Deflection yoke; horizontal coil inductance 0.80 mh ± 10%, 2.7 ohms ± 10% resistance; vertical coil inductance 50 mh ± 10%, 169 ohms ± 10% resistance; current rating a-c peak-to-peak-horizontal coils 200 ma, vertical coils 20 ma. Cleveland Electronics Cat. #VY-140-2-A.	B-7495421-P1

Symbol	Description	GE Drawing
	INDUCTORS (CONTINUED)	
L2	Focus and alignment coil assembly; horizontal and vertical alignment coils shall have d-c resistance of 440 ohms ± 10% and an inductance of 150 mh ± 12% measured at 1 v and 1 kHz across both coils in series (orange to yellow) horizontal and (brown to blue) vertical; focus coil resistance is 634 ohms ± 2½% and shall produce a 40 Gauss field with 40 ma flowing in the winding. Cleveland Electronics Park #VFA248.	B-7495420-P1
L3	Inductance 56 uh ± 5%, max d-c resistance 4.4 ohms. Essex Part #RFC-S-56.	B-7493491-P1
	PLUG	
P2	Power cord with General Insulated #G1-5B or Royal #MP-11 plug.	C-7777121-P2
	RESISTORS (Composition, ± 5%, ¼ w, unless otherwise specified)	
R1	Potentiometer, carbon film; 1 megohm ± 20%, 0.2 w, linear taper. Chicago Telephone Supply Series 70 Control.	C-5494774-P10
R2	1.5 megohm.	C-3R152-P155J
R3	Potentiometer, carbon film; 3.0 megohm ± 30%, 0.2 w, linear taper. Chicago Telephone Supply Series 70 Control.	C-5494774-P12
R4	Potentiometer, miniature, composition, with switch; 1.0 megohm ± 20%, 0.2 w, linear taper.	B-7495316-P11
R5 and R6	2.0 megohm.	C-3R152-P205J
R7	0.47 megohm.	C-3R152-P474J
R8	33,000 ohms.	C-3R152-P333J

Symbol	Description	GE Drawing
	SWITCHES	
S1	Part of R4.	
S2	Toggle type, miniature, dpdt. Alco Electronics Inc. Part #MST-215N.	A-7171932-P2
	TRANSFORMER	
T1	Filament and rectifier, single phase. Pri: 110/117/125 v, 50/60 hertz; sec #1: +190 v ± 5%, 15 ma d-c; sec #2: -25 v ± 5%, 270 ma d-c; sec #3: 6.3 v CT ± 0.189 v, 0.9 amp. (1 rectifier each leg - GE Type 1N1695.)	B-7495381-P1
	TUBE	
V1	GE Type 7735A.	A-7164425-P41
	FUSE HOLDER	
XF1	Bussman Type HKP.	K-7115179-P1
	TUBE SOCKET	
XV1	Mica filled phenolic, for small-button ditetrar 8 pin base tubes. Cinch Cat. #54A18088.	A-7143125-P1

POWER SUPPLY/SWEEP BOARD PL-7673874G1, 2

	CAPACITORS (Electrolytic, tubular, +75% -10%, 25 v d-c w, unless otherwise specified)	
2C1 and 2C2	Electrolytic, solid tantalum type; 6.8 mfd ± 20%, 35 v d-c w. Texas Instrument Type SCM685BP035C4, Sprague Type 150D685X0035B2. (Model 4TE20A1 only.)	B-7493471-P7
2C3	Mylar, dielectric; 0.047 mfd ± 5%, 50 v d-c w. (Model 4TE20A1 only.)	B-7496934-P204

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED) (Electrolytic, tubular, +75% -10%, 25 v d-c w, unless otherwise specified)	
2C4	Mylar, dielectric; 0.1 mfd ± 5%, 50 v d-c w. (Model 4TE20A1 only.)	B-7496934-P206
2C5	50 mfd. Sprague Cat. #30D186A1.	B-7489483-P17
2C6	5.0 mfd. Sprague Cat. #30D179A1.	B-7489483-P6
2C7	Polyester, tubular; 0.01 mfd ± 20%, 100 v d-c w. GE Type 61F.	B-7491930-P5
2C8	5.0 mfd. Sprague Cat. #30D179A1.	B-7489483-P6
2C9	Electrolytic, solid tantalum type; 22 mfd ± 20%, 35 v d-c w. Texas Instrument Type SCM226GP035C4, Sprague Type 150D226X0035R2.	B-7493471-P8
2C11	Mylar, dielectric; 0.0068 mfd ± 5%, 100 v d-c w. GE Type 61F.	B-5491656-P30
2C12	Mylar, dielectric; 0.1 mfd ± 5%, 50 v d-c w.	B-7496934-P206
2C13	15 mfd. Sprague Cat. #30D183A1.	B-7489483-P8
2C14	20 mfd, 50 v d-c w. Sprague Cat. #30D198A1.	B-7489483-P11
2C16	630 mfd +75% -10%, 40 v d-c w. Sprague Type 601D637G040HJ4.	C-7775849-P174
2C17	Mylar, dielectric; 0.15 mfd ± 5%, 50 v d-c w.	B-7496934-P207
2C18	10 mfd. Sprague Cat. #30D182A1.	B-7489483-P7
2C19	Electrolytic, solid tantalum type; 10 mfd ± 20%, 20 v d-c w. Texas Instrument Type SCM106BP020C4, Sprague Type 150D106X0020B2.	B-7493471-P3
2C21	Electrolytic, solid tantalum type; 10 mfd ± 20%, 20 v d-c w. Texas Instrument Type SCM106BP020C4, Sprague Type 150D106X0020B2.	B-7493471-P3
2C22	15 mfd. Sprague Cat. #30D183A1.	B-7489483-P8
2C23	300 mfd +75% -10%, 6 v d-c w. Sprague Cat. #30D139A1.	B-7489483-P24

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED) (Electrolytic, tubular, +75% -10%, 25 v d-c w, unless otherwise specified)	
2C24	Polyester, tubular; 0.47 mfd ± 5%, 100 v d-c w, GE Type 61F.	B-5491656-P4
2C26	20 mfd, 50 v d-c w. Sprague Cat. #30D198A1.	B-7489483-P11
2C27	5.0 mfd. Sprague Cat. #30D179A1.	B-7489483-P6
2C28 and 2C29	Ceramic, Hi-K disk; 0.1 mfd +80% -25%, 500 v d-c w. Sprague Cat. #36C190A.	B-7488160-P3
	RECTIFIERS	
2CR1	Hughes Type HD2254. (Model 4TE20A1 only.)	A-7164424-P23
2CR2	GE Type 1N91.	C-7777664-P1
2CR3	Germanium diode; 80 PIV max. Hughes Type HD2151.	C-7777146-P12
2CR4	U.S. Semcor Type 1N2163.	A-7164424-P42
2CR5	Silicon rectifier; 25 PIV. Power Components Type CL-025.	A-7164424-P144
2CR6 thru 2CR9	Silicon rectifiers; 150 PIV. Power Components Type CL1.5.	A-7164424-P145
2CR10	Silicon rectifier; 25 PIV. Power Components Type CL-025.	A-7164424-P144
2CR11	Zener diode; 18 v ± 10%, 10 w. Power Components Type 10PZ18A.	A-7164424-P148
2CR12	Zener diode; 15 v ± 10%, 1 w. Power Components Type TZ15A.	A-7164424-P147
2CR13	Germanium diode; 80 PIV max. Hughes Type 1N198.	C-7777146-P9
2CR14	Germanium diode; 60 PIV max. Hughes Type 1N90.	C-7777146-P3

Symbol	Description	GE Drawing
	INDUCTORS	
2L1	Variable; 500 uh min, 1000 uh max inductance, 19.8 ohms max d-c resistance, pie winding. (Model 4TE20A1 only.)	
	Camera Serial No. 6000 and under, North Hills Type #PF120J.	B-7491855-P12
	Beginning with Camera Serial No. 6001, Paul Smith, Inc.	B-7399079-P1
2L2	Inductance 10,000 uh ± 10%, d-c resistance 75 ohms max. Aladdin Part #22-105.	B-7493492-P2
2L3	Toriod inductor; inductance 0.75 mh ± 5%, d-c resistance 0.72 ohms max. Torotel Part #15613.	B-7499504-P15
2L4	Inductance 10,000 uh ± 10%, d-c resistance 75 ohms max. Aladdin Part #22-105.	B-7493492-P2
	TRANSISTORS	
2Q1	Fairchild Type 2N3638. (Models 4TE20A1AY and 4TE20A1TY only.)	A-7164451-P184
	GE Type 2N396A. (All other versions of Model 4TE20A1.)	A-7164451-P42
2Q2	GE Type 2N396A.	A-7164451-P42
2Q3	TI Type 2N1040.	A-7164451-P83
2Q4	GE Type 2N396A.	A-7164451-P42
2Q5	Motorola Type 2N3614.	A-7164451-P190
2Q6	GE Type 2N396A.	A-7164451-P42
2Q7	GE Type 2N527.	A-7164451-P82
2Q8	GE Type 2N396A.	A-7164451-P42
2Q9 and 2Q10	Sprague Type 2N597.	A-7164451-P49
2Q11	GE Type 2N526.	A-7164451-P47

Symbol	Description	GE Drawing
	RESISTORS (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified)	
2R1	Precision, carbon film; 681 ohms ± 1%, $\frac{1}{4}$ w. Texas Instrument Corp. Type CD$\frac{1}{4}$R. (Model 4TE20A1 only.)	B-7493565-P2
2R2	Precision, carbon film; 1620 ohms ± 1%, $\frac{1}{4}$ w. Texas Instrument Corp. Type CD$\frac{1}{4}$R. (Model 4TE20A1 only).	B-7493565-P3
2R3	220 ohms. (Model 4TE20A1 only.)	C-3R152-P221J
2R4	Precision, carbon film; 8200 ohms ± 1%, 1/8 w. Mepco Type C-5. (Model 4TE20A1 only.)	B-7493394-P3
2R5	220 ohms, $\frac{1}{2}$ w.	C-3R77-P221J
2R6	470 ohms. (Model 4TE20A1 only.)	C-3R152-P471J
2R7	1000 ohms.	C-3R152-P102J
2R8 and 2R9	2200 ohms.	C-3R152-P222J
2R10	1000 ohms. (Model 4TE20A1 only.)	C-3R152-P102J
2R11	Potentiometer, 1000 ohms ± 20%, 0.5 w. Chicago Telephone Supply Series #65.	B-7497092-P1
2R12	470 ohms.	C-3R152-P471J
2R13	3300 ohms.	C-3R152-P332J
2R14	1000 ohms, $\frac{1}{2}$ w.	C-3R77-P102J
2R15	1000 ohms. (Model 4TE20A1 only.)	C-3R152-P102J
2R16	Potentiometer; 5000 ohms ± 20%, 0.5 w. Chicago Telephone Supply Series #65.	B-7497092-P2
2R17	10,000 ohms.	C-3R152-P103J
2R18	2200 ohms.	C-3R152-P222J
2R19	3900 ohms.	C-3R152-P392J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified)	
2R21 and 2R22	1000 ohms.	C-3R152-P102J
2R23	Potentiometer, carbon film; 500 ohms ± 20%, 0.15 w, linear taper. Chicago Telephone Supply Type UPE-70.	B-7491365-P12
2R24	680 ohms.	C-3R152-P681J
2R25	Potentiometer; 5000 ohms ± 20%, 0.5 w, Chicago Telephone Supply Series #65.	B-7497092-P2
2R26	390 ohms, $\frac{1}{2}$ w.	C-3R77-P391J
2R27 and 2R28	390 ohms.	C-3R152-P391J
2R29	Precision, wirewound; 50 ohms ± 1%, 5 w.	C-7778027-P301
2R30	Potentiometer; 5000 ohms ± 20%, 0.5 w. Chicago Telephone Supply Series #65.	B-7497092-P2
2R31	1000 ohms.	C-3R152-P102J
2R32	12,000 ohms.	C-3R152-P123J
2R33	Potentiometer, carbon film; 25,000 ohms ± 20%, 0.1 w, linear taper. Chicago Telephone Supply Type UPE-70.	B-7491365-P3
2R34	3300 ohms.	C-3R152-P332J
2R35	100 ohms. (Model 4TE20A1 only.)	C-3R152-P101J
2R36	Potentiometer, carbon film; 5000 ohms ± 20%, 0.15 w, linear taper. Chicago Telephone Supply Type UPE-70.	B-7491365-P2
2R37	390 ohms.	C-3R152-P391J
2R38	68 ohms.	C-3R152-P680J
2R40	24,000 ohms.	C-3R152-P243J
2R41	820 ohms, $\frac{1}{2}$ w.	C-3R77-P821J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) **(Composition, ± 5%, ¼ w, unless otherwise specified)**	
2R42	1800 ohms, ½ w.	C-3R77-P182J
2R43	4700 ohms.	C-3R152-P472J
2R44	Potentiometer; 5000 ohms ± 20%, 0.5 w. Chicago Telephone Supply Series #65.	B-7497092-P2
2R46	1000 ohms.	C-3R152-P102J
2R47	27,000 ohms.	C-3R152-P273J
2R49	2200 ohms.	C-3R152-P222J
2R51	47 ohms.	C-3R152-P470J
2R52	82,000 ohms, ½ w.	C-3R77-P823J
2R53	68,000 ohms.	C-3R152-P683J
2R54	470 ohms.	C-3R152-P471J
2R56	2200 ohms.	C-3R152-P222J
2R57 and 2R58	220 ohms.	C-3R152-P221J
2R60	68,000 ohms.	C-3R152-P683J
2R61	100 ohms.	C-3R152-P101J
	TRANSFORMER	
2T1	Pulse transformer. Pri d-c resistance: 12.2 ohms ± 30%; sec #1 d-c resistance: 13.0 ohms ± 30%; sec #2 d-c resistance: 14.2 ohms ± 30%. (Model 4TE20A1 only.)	B-7493382-P1
	TRANSISTOR SOCKETS	
2XQ1	Transistor socket assembly. (Model 4TE20A1 only.)	PL-7380029-G2

Symbol	Description	GE Drawing
	TRANSISTOR SOCKETS (CONTINUED)	
2XQ2 thru 2XQ4	Transistor socket assemblies.	PL-7380029-G2
2XQ6 thru 2XQ11	Transistor socket assemblies.	PL-7380029-G2

VIDEO BOARD
PL-7673873G1, 2

CAPACITORS
(Electrolytic, tubular, +75% -10%, 25 v d-c w, unless otherwise specified)

3C1	Silver mica; 510 mmfd ± 5%, 500 v d-c w.	A-4029003-P1
3C2	Ceramic, Hi-K disk; 0.005 mfd +100% -0%, 500 v d-c w.	C-7774750-P11
3C3	Mylar, dielectric; 0.047 mfd ± 20%, 50 v d-c w.	B-7496934-P4
3C4	16 mfd +50% -10%, 250 v d-c w. GE Cat. #43F7647AA1.	C-7775849-P17
3C5	Ceramic, Hi-K disk; 0.1 mfd +80% -30%, 50 v d-c w. Sprague Cat. #36C172.	A-7161189-P2
3C6	20 mfd +50% -10%, 300 v d-c w. Sprague Type 39D206F300FJ4.	C-7775849-P173
3C7 and 3C8	20 mfd, 50 v d-c w. Sprague Cat. #30D198A1.	B-7489483-P11
3C9	Variable ceramic; 8 to 50 mmfd -100% +0% min, -0% +50% max, -750 temp coef. Erie Series 557, Dielectric Type Code E.	B-7493393-P102
3C11	Silver mica, epoxy dipped; 1800 mmfd ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496932-P14
3C12	Variable, mica; 170 to 780 mmfd. Electromotive Type 46W.	M-7478644-P10

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED) (Electrolytic, tubular, +75% -10%, 25 v d-c w, unless otherwise specified)	
3C13	Variable, ceramic; 3 to 12 mmfd -100% +0% min, -0% +50% max. Erie Series 557, Dielectric Type Code A.	B-7493393-P103
3C14	10 mfd. Sprague Cat. #30D182A1.	B-7489483-P7
3C16	100 mfd. Sprague Cat. #30D188A1.	B-7489483-P18
3C17	300 mfd, 6 v d-c w. Sprague Cat. #30D139A1.	B-7489483-P24
3C18	10 mfd. Sprague Cat. #30D182A1.	B-7489483-P7
3C20	Polyester, tubular; 0.01 mfd ± 20%, 100 v d-c w. GE Type 61F.	B-7491930-P5
3C21	15 mfd. Sprague Cat. #30D183A1.	B-7489483-P8
3C22	Variable, ceramic; 3 to 12 mmfd -100% +0% min, -0% +50% max. Erie Series 557, Dielectric Type Code A.	B-7493393-P103
3C23	35 mfd, 15 v d-c w. Sprague Cat. #30D169A1.	B-7489483-P10
3C24	Mylar, dielectric; 0.22 mfd ± 20%, 50 v d-c w.	B-7496934-P8
3C26	20 mfd, 50 v d-c w. Sprague Cat. #30D198A1.	B-7489483-P11
3C27	100 mfd, 6 v d-c w. Sprague Cat. #30D135A1.	B-7489483-P9
3C28	15 mfd. Sprague Cat. #30D183A1.	B-7489483-P8
3C29	35 mfd, 15 v d-c w. Sprague Cat. #30D169A1.	B-7489483-P10
3C30	Silver mica, epoxy dipped; 470 mmfd ± 5%, 300 v d-c w. Electromotive Type DM15.	B-7489162-P43
3C31	Silver mica, epoxy dipped; 150 mmfd ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P31
3C32	Electrolytic, solid tantalum type; 6.8 mfd ± 20%, 35 v d-c w. Texas Instrument Type SCM685BP035C4, Sprague Type 150D685X0035B2.	B-7493471-P7
3C33 and 3C34	2.0 mfd +50% -10%, 475 v d-c w.	C-7774786-P48

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED) (Electrolytic, tubular, +75% -10%, 25 v d-c w, unless otherwise specified)	
3C36	4.0 mfd +100% -10%, 250 v d-c w. Sprague Cat. #42D4S7268.	C-7779696-P1
3C37	5.0 mfd. Sprague Cat. #30D179A1.	B-7489483-P6
3C38	Silver mica, epoxy dipped; 3300 mmfd ± 5%, 500 v d-c w. Electromotive Type DM20.	A-7147203-P20
3C39	Silver mica, epoxy dipped; 1000 mmfd ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496932-P8
3C41	5.0 mfd. Sprague Cat. #30D179A1.	B-7489483-P6
3C42 and 3C43	Ceramic, Hi-K disk; 0.1 mfd +80% -30%, 50 v d-c w. Sprague Cat. #36C172.	A-7161189-P2
3C47	Silver mica, epoxy dipped; 150 mmfd ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P31
3C52	Electrolytic, solid tantalum type; 220 mfd ± 10%, 10 v d-c w. Texas Instrument Type SCM227HP010C2, Sprague Type 150D227X9010S2.	B-7493471-P109
	RECTIFIERS	
3CR1 thru 3CR4	Silicon rectifiers; 600 PIV. Power Components Type CL-6.	A-7164424-P143
3CR5	Silicon diode. Hughes Type 1N459.	A-7166006-P1
3CR6 and 3CR7	Zener diodes; 150 v ± 5%, 1 w. Power Components Type TZ150.	A-7172767-P148
3CR8	Zener diode. Hughes Type 1N752A.	A-7164424-P90
3CR9 thru 3CR12	Silicon rectifiers; 25 PIV. Power Components Type CL-025.	A-7164424-P144
3CR13 and 3CR14	Silicon diodes. Hughes Type 1N459.	A-7166006-P1

Symbol	Description	GE Drawing
	DELAY LINE	
3DL1	Delay line, distributed constant; delay of 1.5 microseconds ± 5%, impedance shall be 3900 ohms ± 20%, attenuation shall not exceed 0.3 db, operating temp range -25 C to +85 C. Technitrol Inc. Part #C25JTS-3900-150.	B-7495249-P1
	INDUCTORS	
3L1	RF choke; inductance 15 uh ± 10%, d-c resistance 1.2 ohms max. Jeffers Cat. #4421-9.	B-7498929-P18
3L2	Coil, variable; inductance 18 to 36 uh, d-c resistance 2.3 ohms max. North Hills Type PF120E.	B-7491855-P107
	TRANSISTORS	
3Q1	Sprague Type 2N502A.	A-7164451-P43
3Q2 thru 3Q4	Sprague Type 2N2048.	A-7164451-P112
3Q5	GE Type 2N706.	A-7164451-P116
3Q6 and 3Q7	Sprague Type 2N2048.	A-7164451-P112
3Q8 and 3Q9	TI Type 2N1304.	A-7164451-P93
3Q10	GE Type 2N656A.	A-7164451-P154
	RESISTORS (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified)	
3R1	51 megohm.	C-3R152AA-P516J
3R2	10 megohm.	C-3R152-P106J
3R3	0.47 megohm.	C-3R152-P474J
3R4	1.0 megohm.	C-3R152-P105J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified)	
3R5	Composition; 1000 megohm ± 20%, $\frac{1}{2}$ w.	C-3R77AA-P108
3R6	1.5 megohm.	C-3R152-P155J
3R7	47 megohm.	C-3R152-P470J
3R8	3900 ohms, $\frac{1}{2}$ w.	C-3R77-P392J
3R9	18,000 ohms, 2 w.	C-3R79-P183J
3R10	33,000 ohms.	C-3R152-P333J
3R11	10,000 ohms.	C-3R152-P103J
3R12	8200 ohms.	C-3R152-P822J
3R13	750 ohms.	C-3R152-P751J
3R14	1500 ohms.	C-3R152-P152J
3R15	100 ohms.	C-3R152-P101J
3R16	3900 ohms.	C-3R152-P392J
3R17	Potentiometer, carbon film; 1000 ohms ± 20%, 0.15 w, linear taper. Chicago Telephone Supply Type UPE-70.	B-7491365-P1
3R18	330 ohms.	C-3R152-P331J
3R19	6800 ohms.	C-3R152-P682J
3R20	0.10 megohm.	C-3R152-P104J
3R21	Potentiometer, carbon film; 1000 ohms ± 20%, 0.15 w, linear taper. Chicago Telephone Supply Type UPE-70.	B-7491365-P1
3R22	9100 ohms.	C-3R152-P912J
3R23	1200 ohms.	C-3R152-P122J
3R24	5600 ohms.	C-3R152-P562J
3R26	47 ohms.	C-3R152-P470J
3R27	2200 ohms.	C-3R152-P222J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified)	
3R29	2200 ohms.	C-3R152-P222J
3R31	1800 ohms.	C-3R152-P182J
3R32	3000 ohms.	C-3R152-P302J
3R33	470 ohms.	C-3R152-P471J
3R34	4700 ohms.	C-3R152-P472J
3R36 and 3R37	10,000 ohms.	C-3R152-P103J
3R38	8200 ohms.	C-3R152-P822J
3R39	1000 ohms.	C-3R152-P102J
3R40	100 ohms.	C-3R152-P101J
3R41	68 ohms.	C-3R152-P680J
3R42	680 ohms.	C-3R152-P681J
3R43	390 ohms.	C-3R152-P391J
3R44	68 ohms.	C-3R152-P680J
3R46	68 ohms.	C-3R152-P680J
3R47	2200 ohms.	C-3R152-P222J
3R48	0.10 megohm.	C-3R152-P104J
3R49	0.18 megohm.	C-3R152-P184J
3R51	1500 ohms, $\frac{1}{2}$ w.	C-3R77-P152J
3R52	Precision, carbon film; 100 ohms ± 10%, $\frac{1}{4}$ w. Texas Instrument Type CD$\frac{1}{4}$R.	B-7493565-P6
3R54	22 ohms.	C-3R152-P220J
3R56	1000 ohms.	C-3R152-P102J

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified)	
3R57	22,000 ohms.	C-3R152-P223J
3R58	3000 ohms.	C-3R152-P302J
3R59	22,000 ohms.	C-3R152-P223J
3R60	100 ohms.	C-3R152-P101J
	TUBE	
3V1	RCA Type 7586 Nuvistor.	A-7164416-P80
	TRANSISTOR SOCKETS	
3XQ1 thru 3XQ10	Transistor socket assemblies. (3XQ1 applies to Model 4TE20A1 only.)	PL-7380029-G2
	TUBE SOCKET	
3XV1	Nuvistor socket. Cinch Cat. #133-65-10-001.	B-7494661-P1

CRYSTAL OSCILLATOR MODULE
PL-7499748G1, 2
(Model 4TE20A1 Only)

	CAPACITORS	
C1	Mylar, dielectric; 0.01 mfd ± 20%, 50 v d-c w.	B-7496934-P1
C2	Silver mica, epoxy dipped; 3300 pf ± 2%, 500 v d-c w. Electromotive Type DM15.	B-7496932-P220
C3	Electrolytic, tubular; 5.0 mfd +75% -10%, 25 v d-c w. Sprague Cat. #30D179A1.	B-7489483-P6
C4	Silver mica, epoxy dipped; 1500 pf ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496932-P12
C5	Polyester, tubular; 0.0047 mfd ± 20%, 100 v d-c w. GE Type 61F.	B-7491930-P3

Symbol	Description	GE Drawing
	RECTIFIER	
CR1	Silicon diode. Hughes Type 1N629.	C-5494923-P5
	TRANSISTOR	
Q1	GE Type 2N3415.	A-7164451-P213
	RESISTORS (Composition, ± 5%, $\frac{1}{4}$ w.)	
R1	0.43 megohm.	C-3R152-P434J
R2	47,000 ohms.	C-3R152-P473J
R3	2200 ohms.	C-3R152-P222J
R4	22,000 ohms.	C-3R152-P223J
R5	30,000 ohms.	C-3R152-P303J
	CRYSTALS	
Y1	Frequency 15.75 kHz. (Group 1 only.)	B-7499796-P1
Y1	Frequency 20.25 kHz. (Group 2 only.)	B-7499796-P2

CRYSTAL OSCILLATOR BOARD PL-7799576G1 (Model 4TE20A2 Only)

	CAPACITORS	
C1	Polyester, tubular; 0.0022 mfd ± 5%, 100 v d-c w. GE Type 61F.	B-5491656-P27
C2	Silver mica, epoxy dipped; 390 pf ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496931-P41
C3	Silver mica, epoxy dipped; 1000 pf ± 5%, 500 v d-c w. Electromotive Type DM15.	B-7496932-P8
C4	Ceramic, Hi-K disk; 0.005 mfd +80% -20%, 50 v d-c w. Sprague Cat. #40C141.	B-7491827-P1

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED)	
C5	Electrolytic, aluminum; 5.0 mfd +150% -10%, 25 v d-c w. Matsushita Electric Part #ECE-A-25V-5.	C-7781881-P1
	RECTIFIERS	
CR1 and CR2	GE Type 1N4454.	A-7164424-P104
	TRANSISTORS	
Q1 thru Q4	GE Type 2N3415.	A-7164451-P213
	RESISTORS (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified)	
R1	68,000 ohms.	C-3R152-P683J
R2	1000 ohms.	C-3R152-P102J
R3	4700 ohms.	C-3R152-P472J
R4	0.51 megohm.	C-3R152-P514J
R5 and R6	10,000 ohms.	C-3R152-P103J
R7 and R8	2200 ohms.	C-3R152-P222J
R9	Precision; 12.1 ohms ± 1%, $\frac{1}{4}$ w.	C-3R166-P12R1
R10	10,000 ohms.	C-3R152-P103J
R11	1800 ohms.	C-3R152-P182J
	CRYSTAL	
Y1	Frequency 20.25 kc.	B-7499796-P2

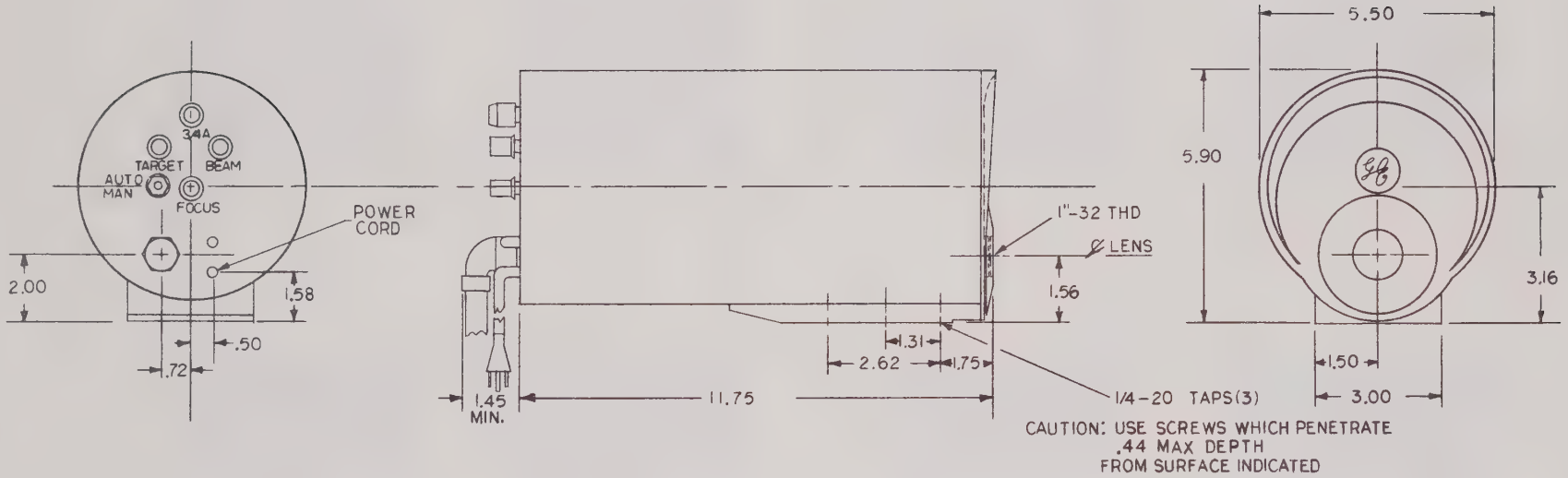


Fig. 1 Camera Outline Diagram (C-7781821)

EBI-6136A

Fig. 2 2Q1 Emitter Waveform

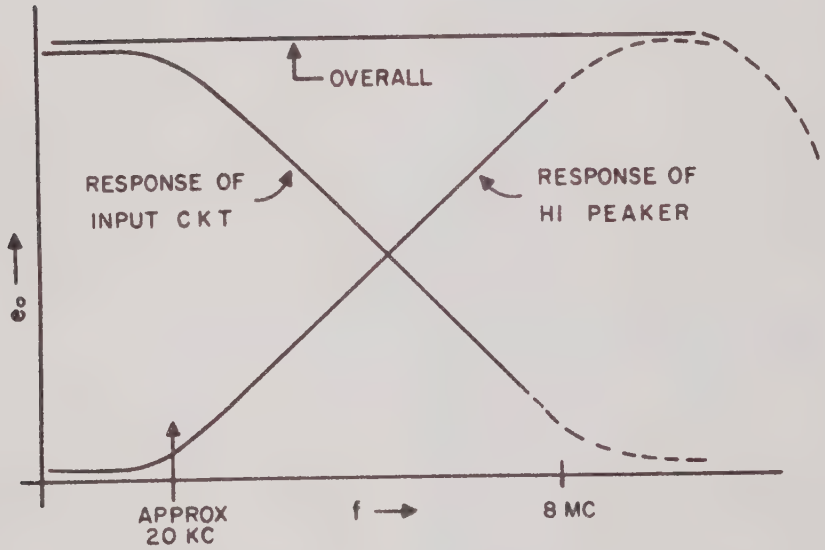


Fig. 3 Response of Input Coupling Circuit

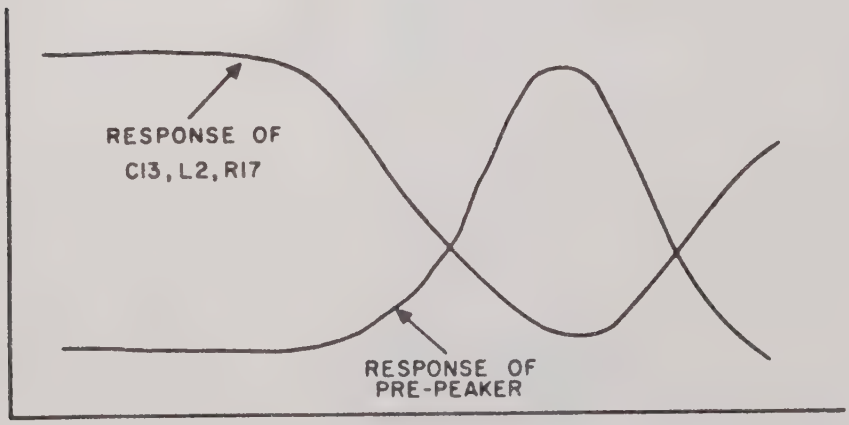
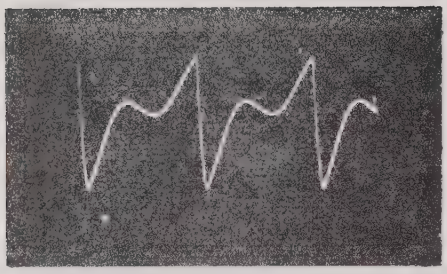
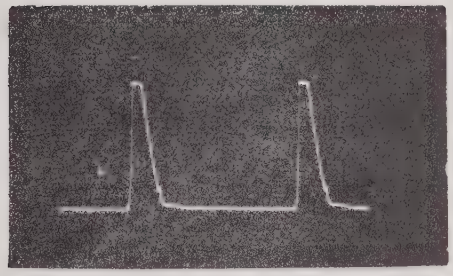


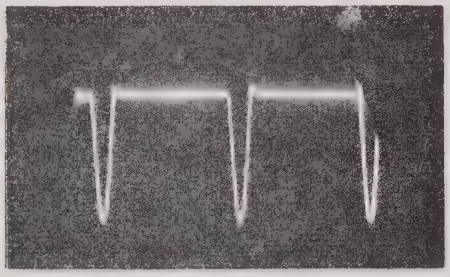
Fig. 4 High Peaker Signal Output



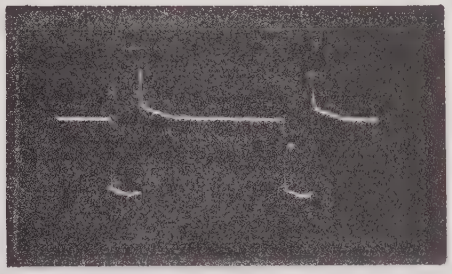
(a) 2Q1, Emitter, 6.3 Microseconds Wide, 2.5 V P-P



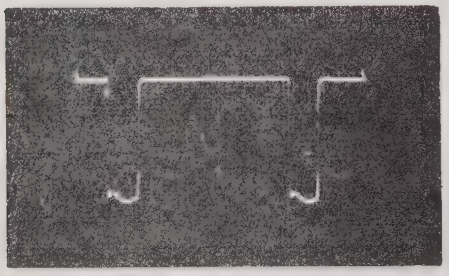
(b) 2Q2, Collector, 10 V P-P, H Rate



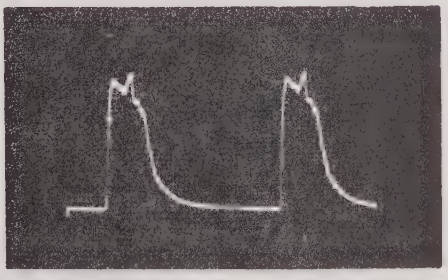
(c) 2Q3 Collector, Horizontal Sweep
Amplitude = 30-60 V
Flyback Time = 12 Microseconds
H Rate



(d) 2Q4, Base, 6 V P-P, H Rate

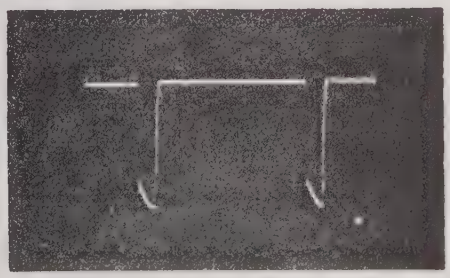


(e) 2Q4, Emitter, 12 Microseconds Wide, 2.8 V P-P, H Rate



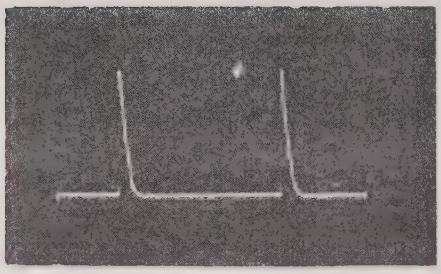
(f) 2Q4, Collector, 15 V P-P, H Rate

(g) 2Q6, Collector, 2Q7, Base, 3.0 V P-P, V Rate

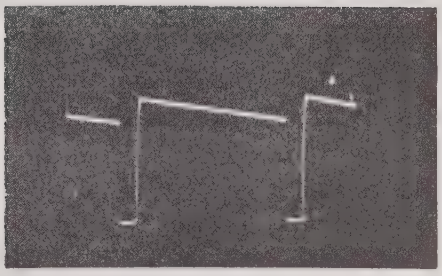


(h) 2Q8, Collector, 6 V P-P, V Rate

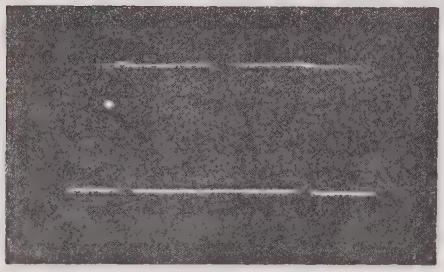
Fig. 5 Power Supply/Sweep Board Waveforms (a-h)



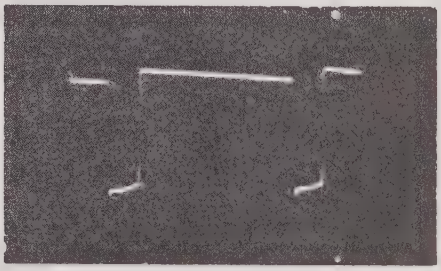
(i) 2Q8, Base, 2 V P-P, V Rate



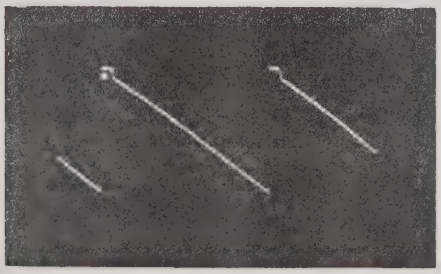
(j) 2Q9, Base, 6 V P-P, V Rate



(k) 2Q9 and 2Q10, Collector, Composite Camera Blanking, 38 V P-P, V Rate (Same pulse used at junction of R54 and R56 for clamp only, 5 V P-P)

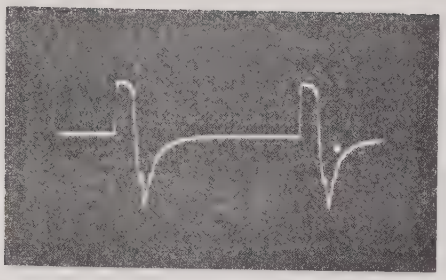


(l) 2Q10, Base, 3 V P-P, H Rate

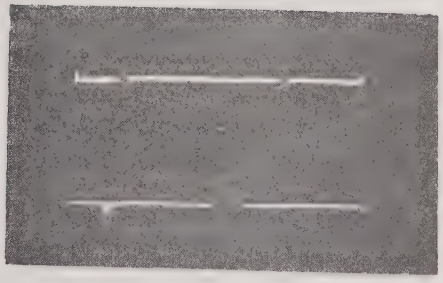


(m) Vertical Sweep, Positive Side of 2C23
Saw Portion = 2.7 V P-P
Step Portion = 0.3 V P-P

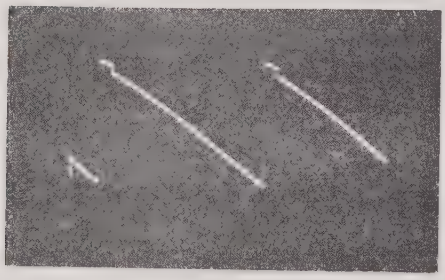
Fig. 6 Power Supply/Sweep Board Waveforms (i-m)



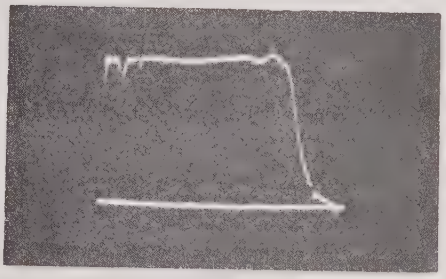
(a) 3Q8, Base, 5.5 V P-P, H Rate



(b) 3Q8 and 3Q9, Collector, Composite Sync, 20 V P-P, V Rate

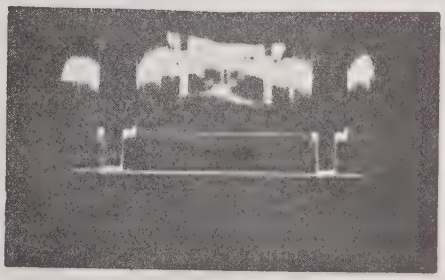


(c) 3Q9, Base, 3 V P-P, V Rate



(d) Over-all Frequency Response with Last Marker at 10 MC

(e) Camera Video Output into 75 ohms, Lens at f5.6, 1.0 V P-P, V Rate



(f) Camera Video Output into 75 ohms, Lens at f5.6, 1.0 V P-P, H Rate

Fig. 7 Video Board Waveforms (a-f)

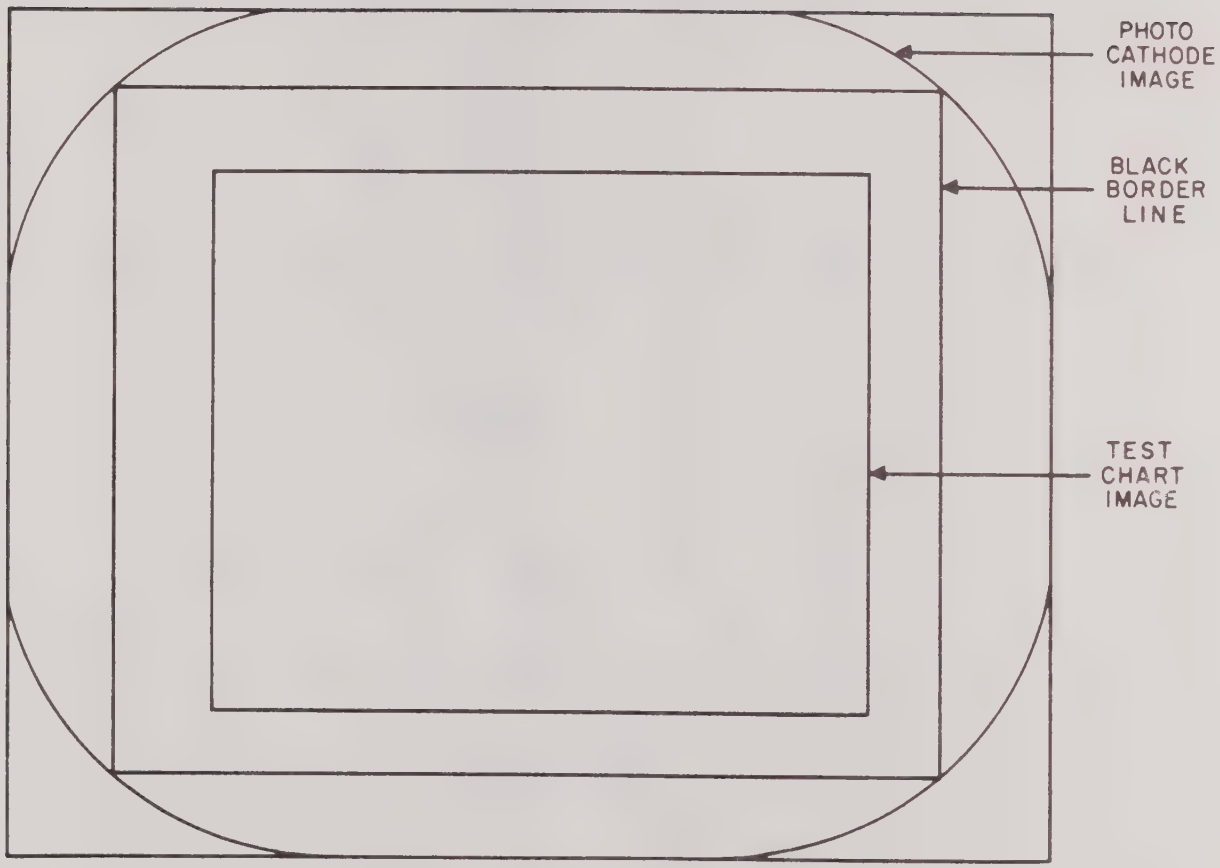
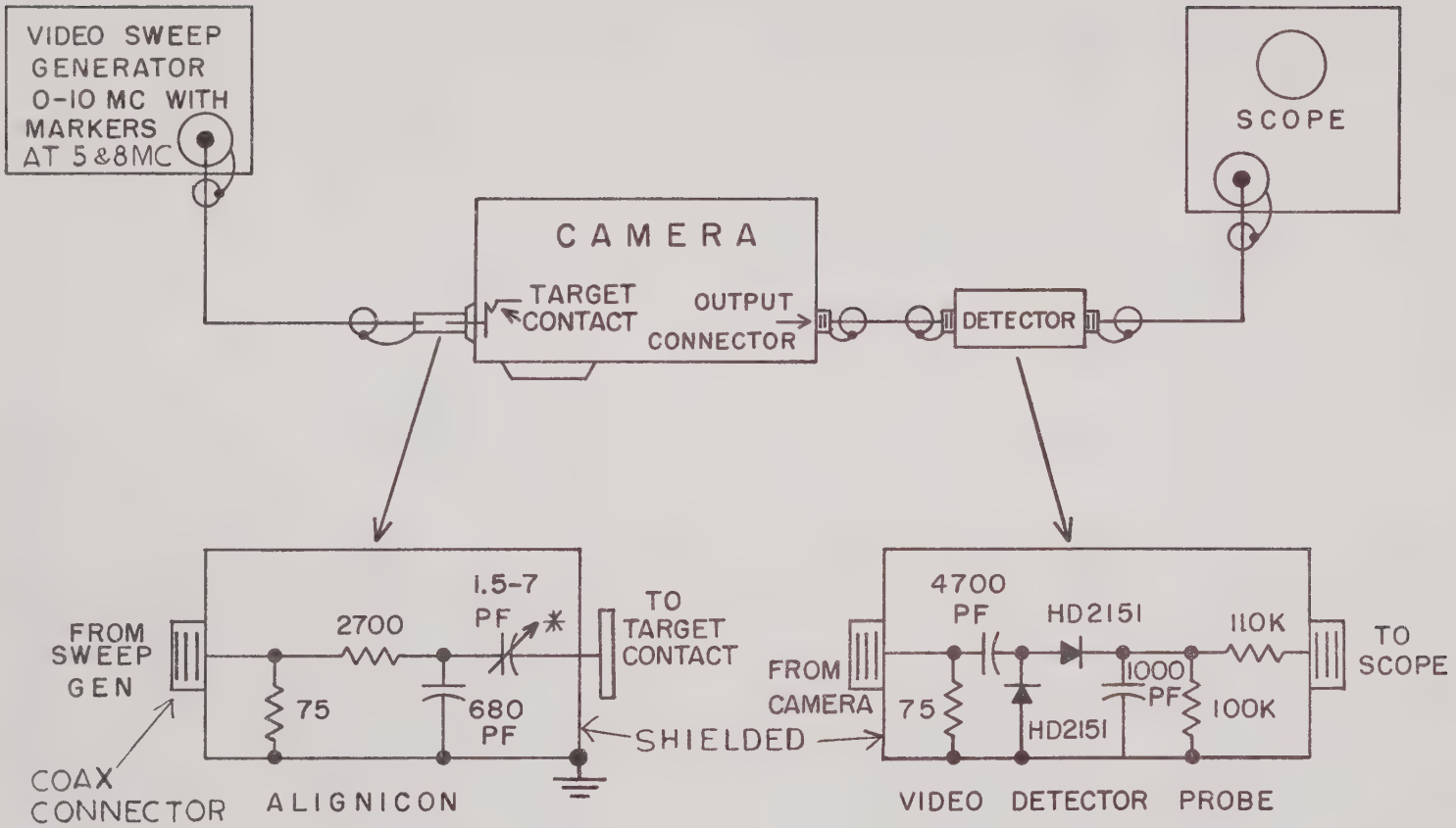


Fig. 8 Photocathode Image on Monitor Screen



* CONNECT TARGET CONTACT RING AND ALIGNICON CASE DIRECTLY TO A CAPACITY BRIDGE AND ADJUST THE 1.5-7PF TRIMMER FOR 9.0 PF.

Fig. 9 Equipment and Setup for Frequency Response Alignment (B-7497294, Sheet 1, Rev. A)

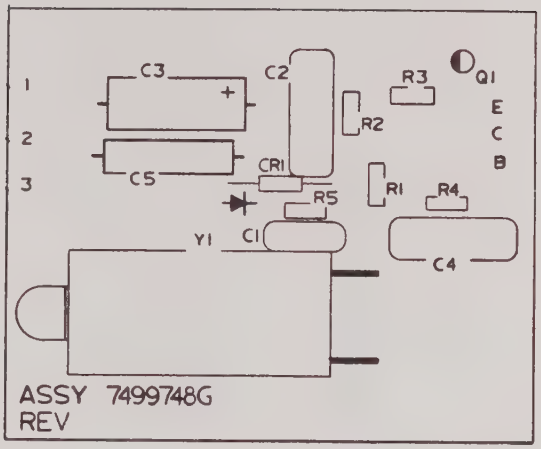
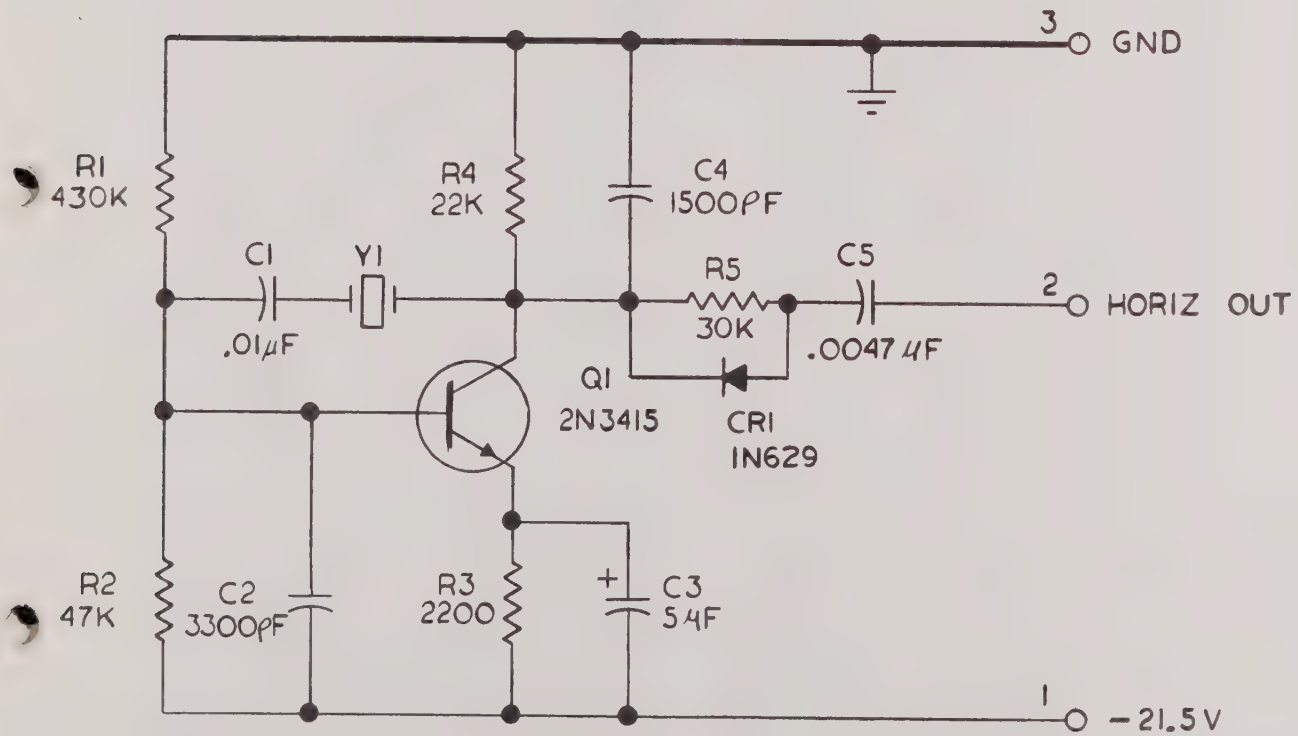


Fig. 10 Model 4TE20A1 Accessory Crystal Oscillator Module Component Location Diagram (B-7499749, Rev. A)



NOTES:

1. RESISTOR VALUES ARE IN OHMS ¢ 1/4 WATT ±5 %

Fig. 11 Model 4TE20A1 Accessory Crystal Oscillator Module Schematic Diagram (B-7499750, Rev. B)

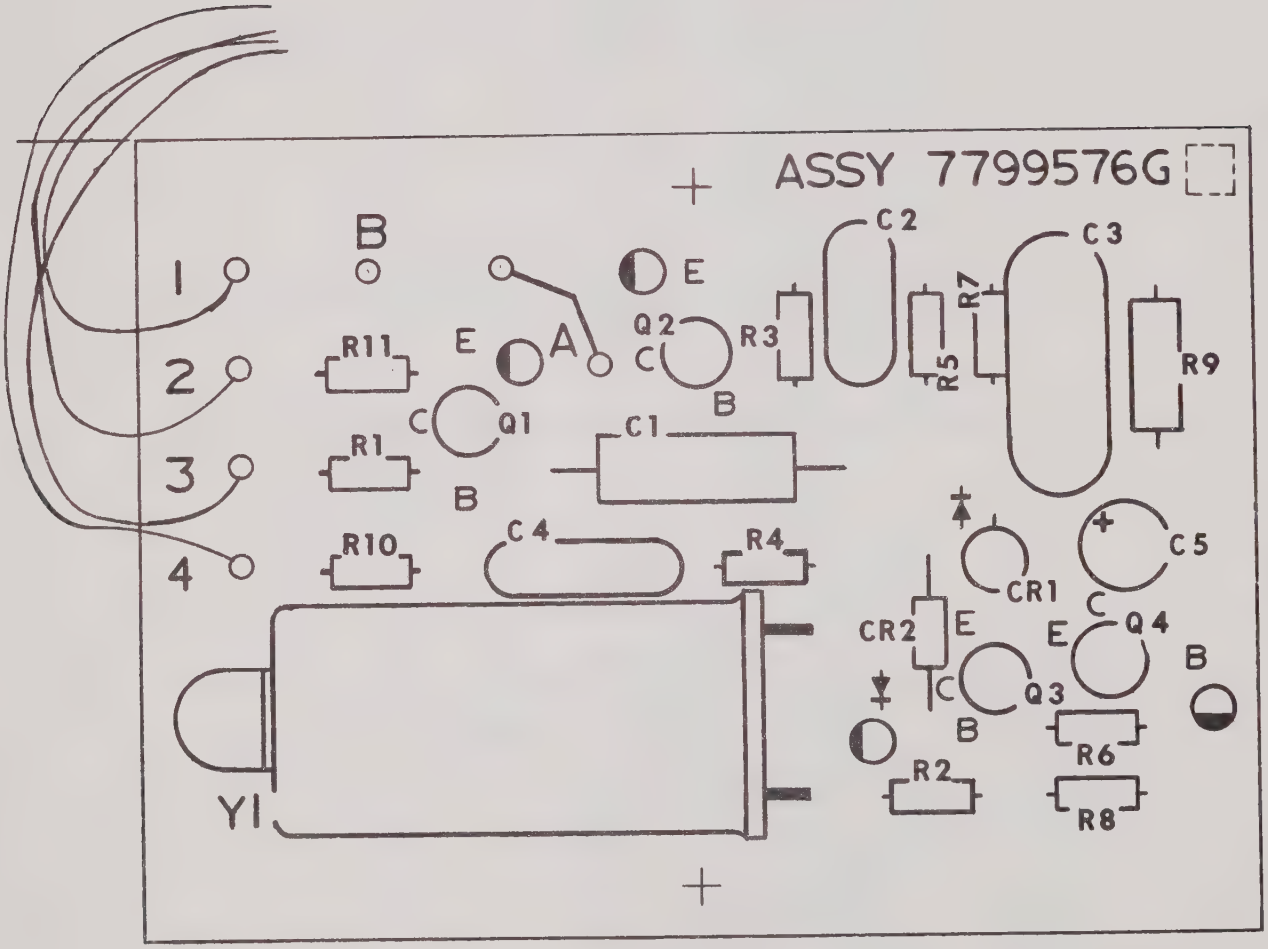
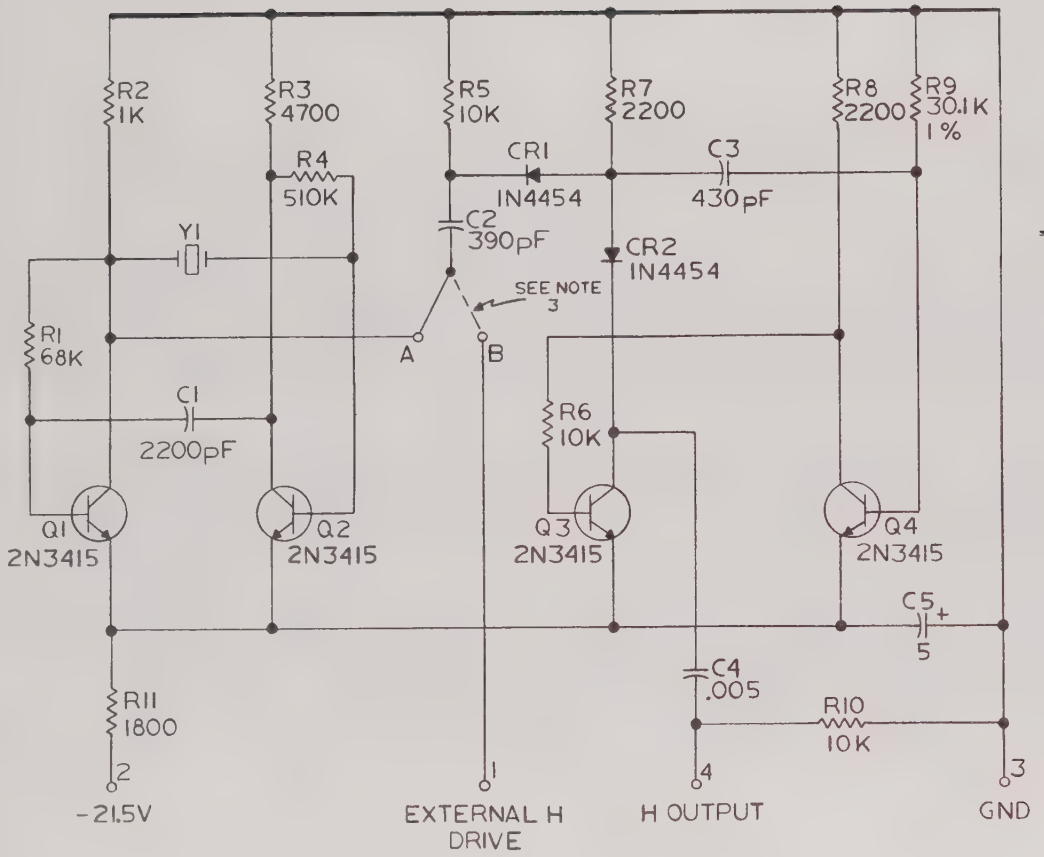


Fig. 12 Model 4TE20A2 Crystal Oscillator Board Component Location Diagram
(C-7799576, Rev. B)



NOTES

1- RESISTOR VALUES ARE IN OHMS AND 1/4 WATT ± 5% UNLESS OTHERWISE SHOWN
2- CAPACITOR VALUES ARE IN MICRO-FARADS UNLESS OTHERWISE SHOWN
3- FOR INTERNAL DRIVE, JUMPER TO "A" AS SHOWN. FOR EXTERNAL DRIVE JUMPER TO "B"

Fig. 13 Model 4TE20A2 Crystal Oscillator Board Schematic Diagram (C-7799577, Rev. A)

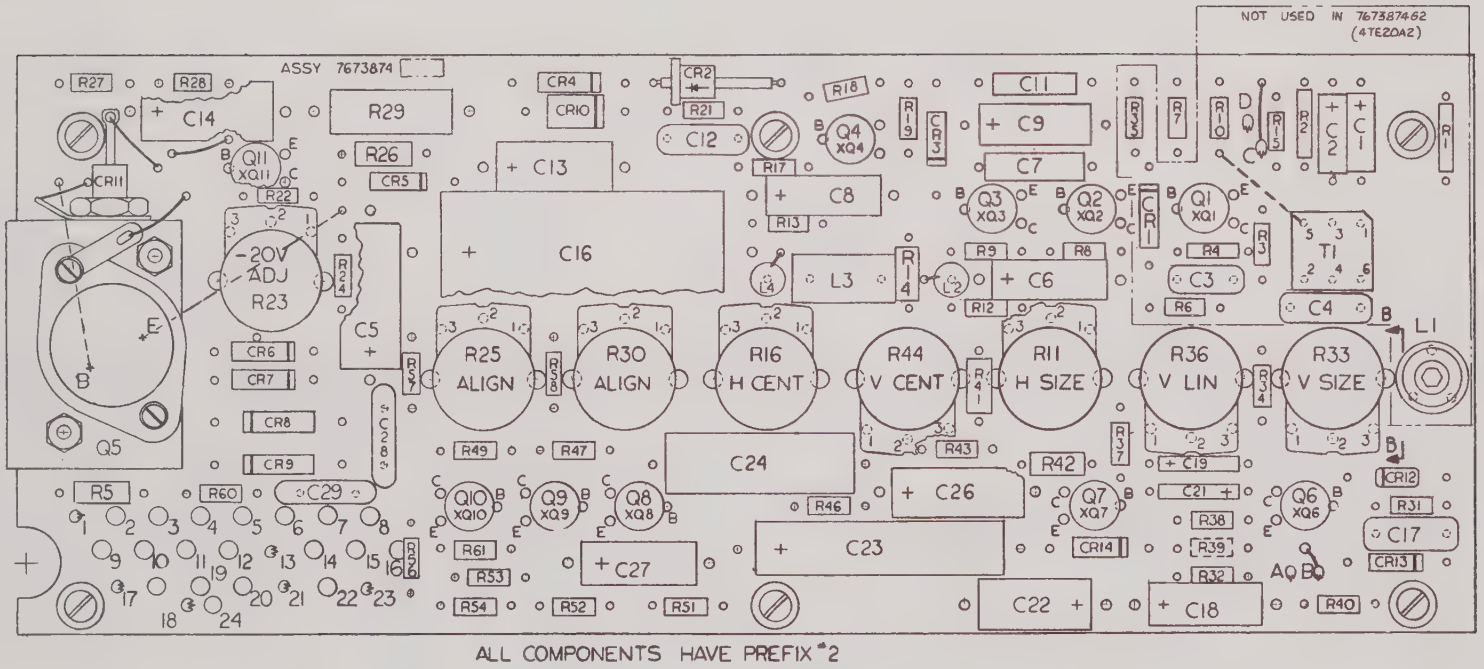
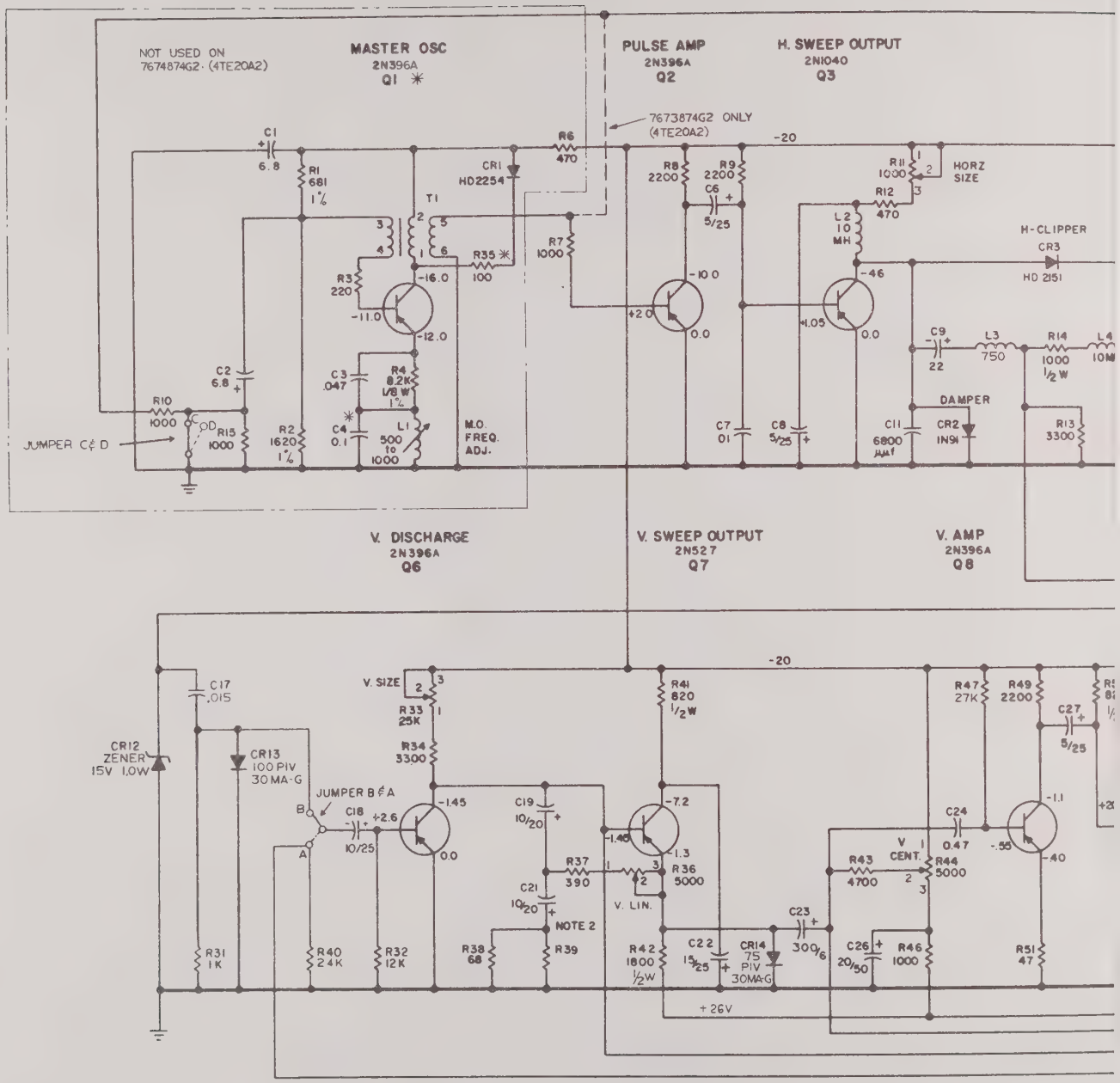
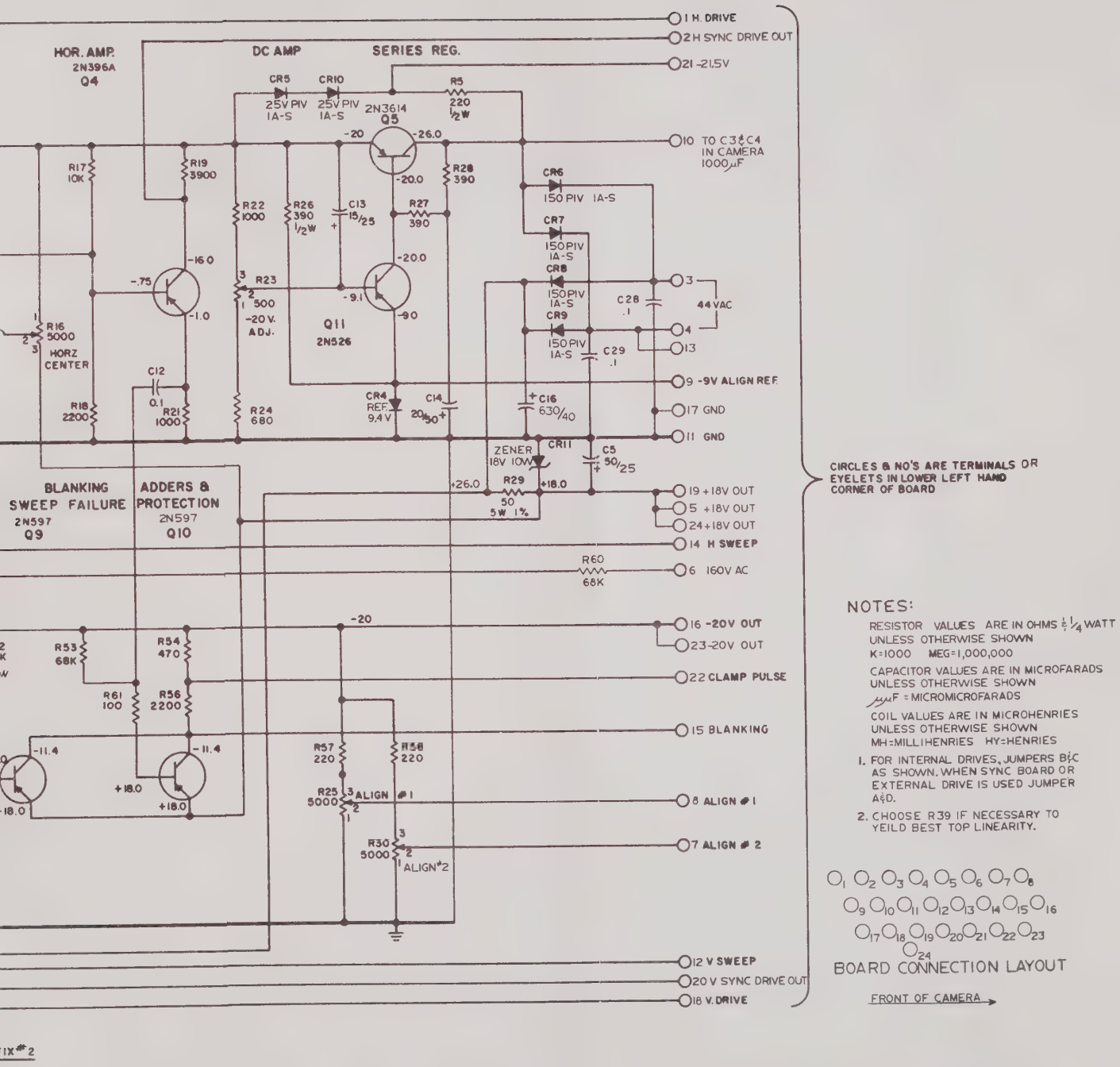


Fig. 14 Power Supply/Sweep Board Component Location Diagram (D-7673874, Sheet 1, Rev. L)



✳ FOR CAMERA 4TE20A1AY
Q1 TO BE 2N3638A
C4 TO BE .047µF
R35 TO BE 10Ω

ALL SYMBOL NO'S HAVE PRE



NOTES:

RESISTOR VALUES ARE IN OHMS ± 1/4 WATT UNLESS OTHERWISE SHOWN
K=1000 MEG=1,000,000

CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SHOWN
μμF = MICROMICROFARADS

COIL VALUES ARE IN MICROHENRIES UNLESS OTHERWISE SHOWN
MH=MILLIHENRIES HY=HENRIES

1. FOR INTERNAL DRIVES, JUMPERS B & C AS SHOWN. WHEN SYNC BOARD OR EXTERNAL DRIVE IS USED JUMPER A & D.
2. CHOOSE R39 IF NECESSARY TO YEILD BEST TOP LINEARITY.

BOARD CONNECTION LAYOUT

FRONT OF CAMERA →

Fig. 15 Power Supply/Sweep Board Schematic Diagram (DD-7673874, Sheet 2, Rev. K)

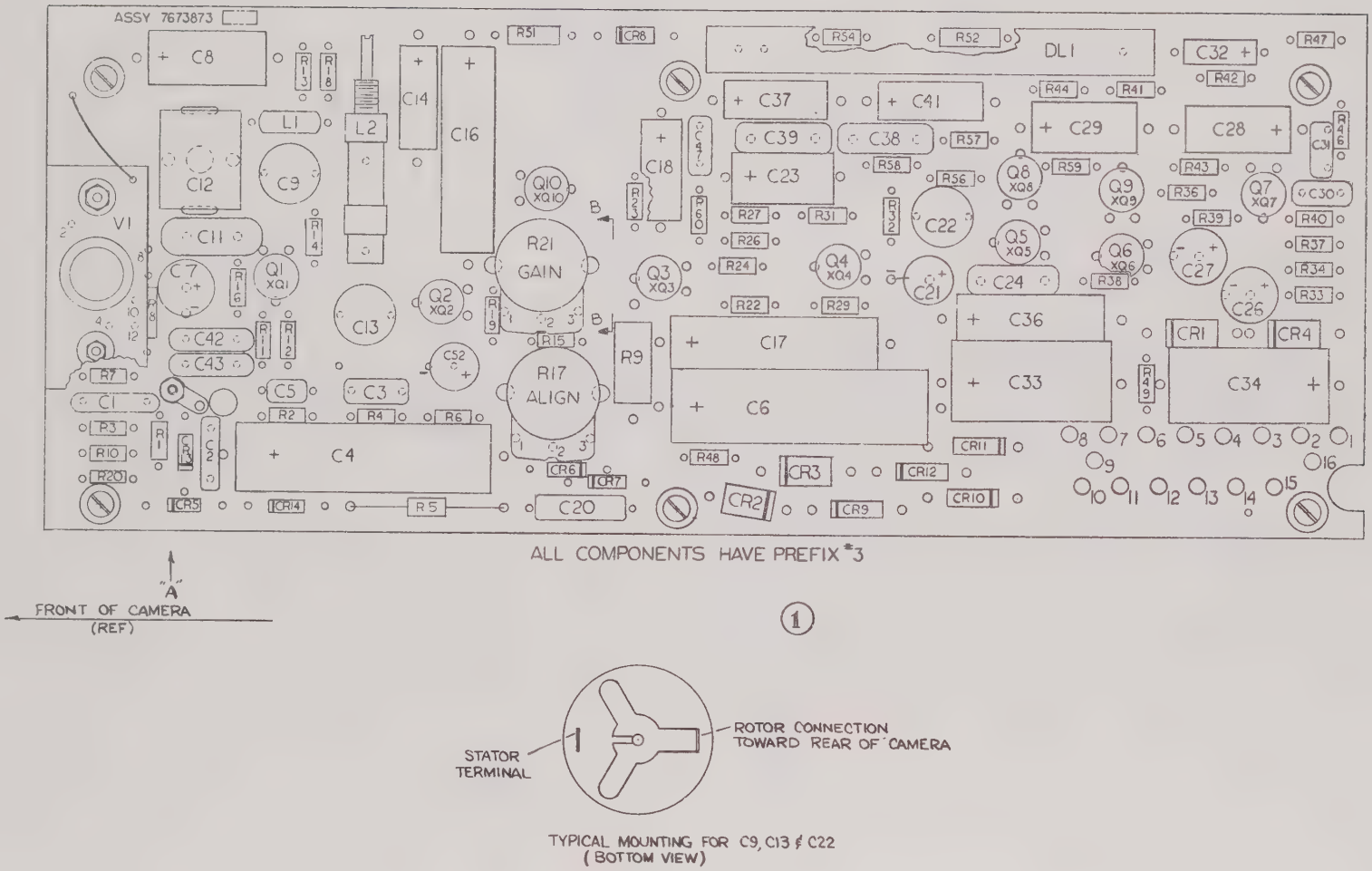
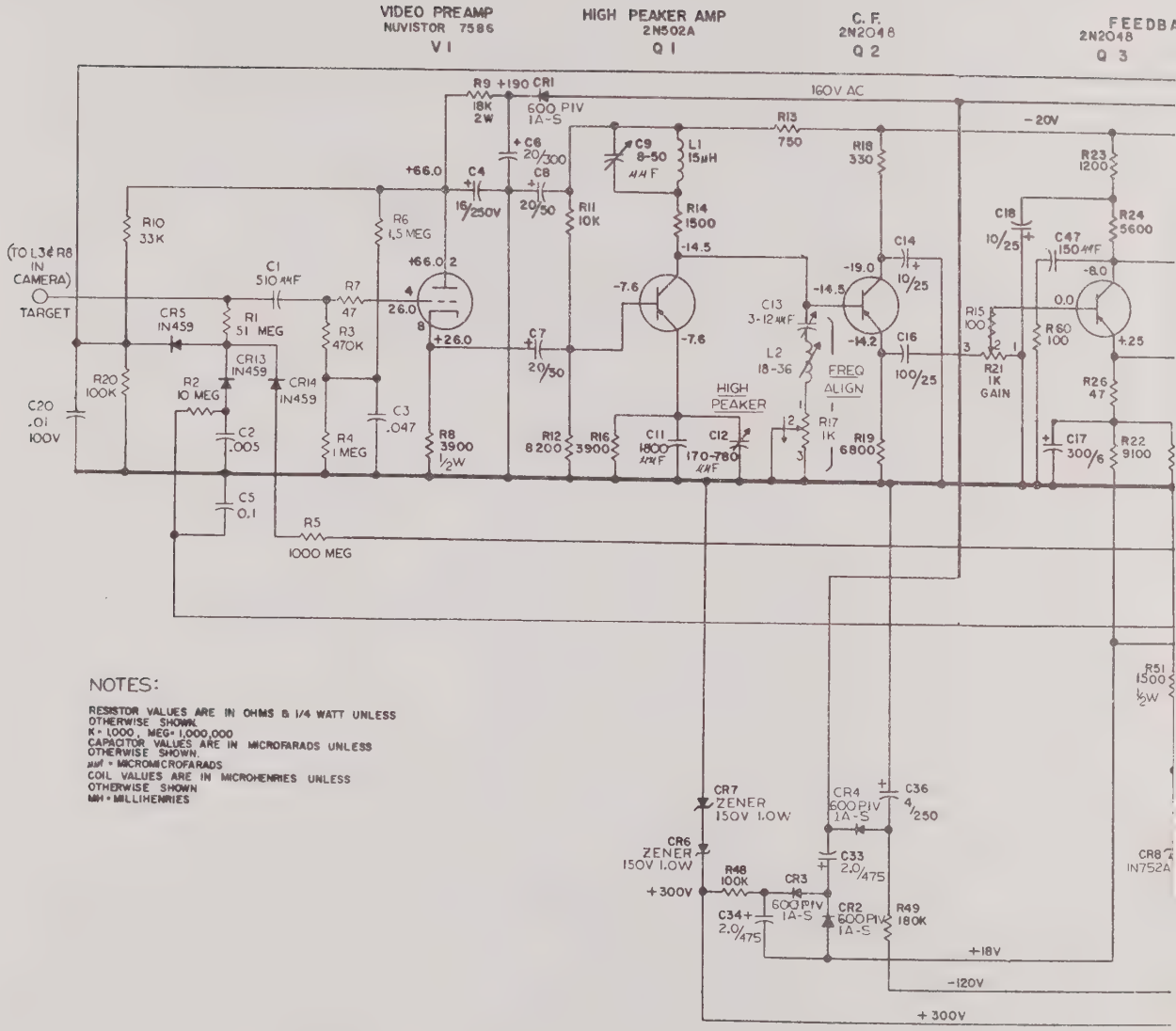


Fig. 16 Video Board Component Location Diagram (D-7673873, Sheet 1, Rev. E)



NOTES:

RESISTOR VALUES ARE IN OHMS & 1/4 WATT UNLESS OTHERWISE SHOWN.
K = 1,000 , MEG = 1,000,000
CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SHOWN.
µµf = MICROMICROFARADS
COIL VALUES ARE IN MICROHENRIES UNLESS OTHERWISE SHOWN
MH = MILLIHENRIES

ALL

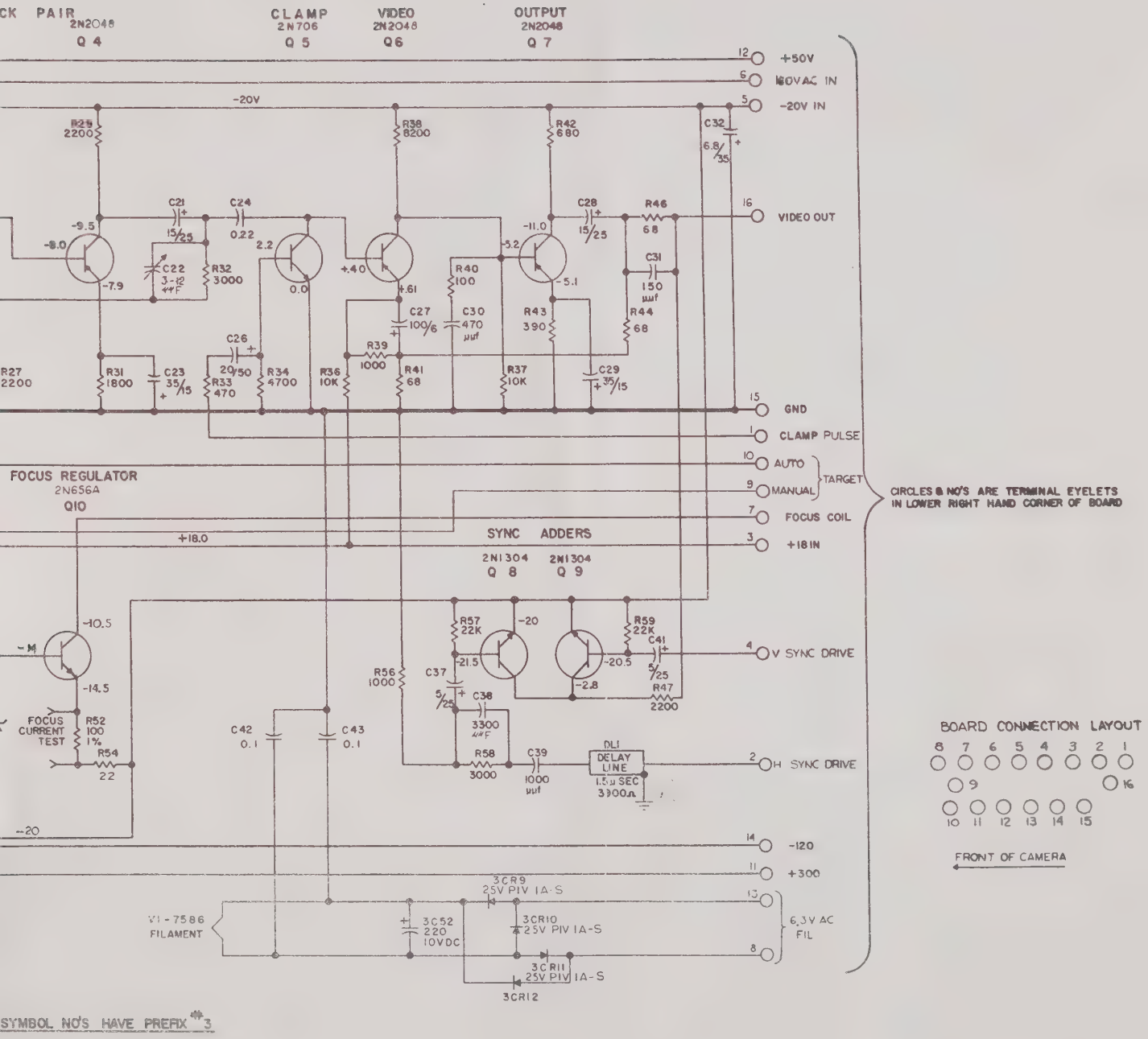
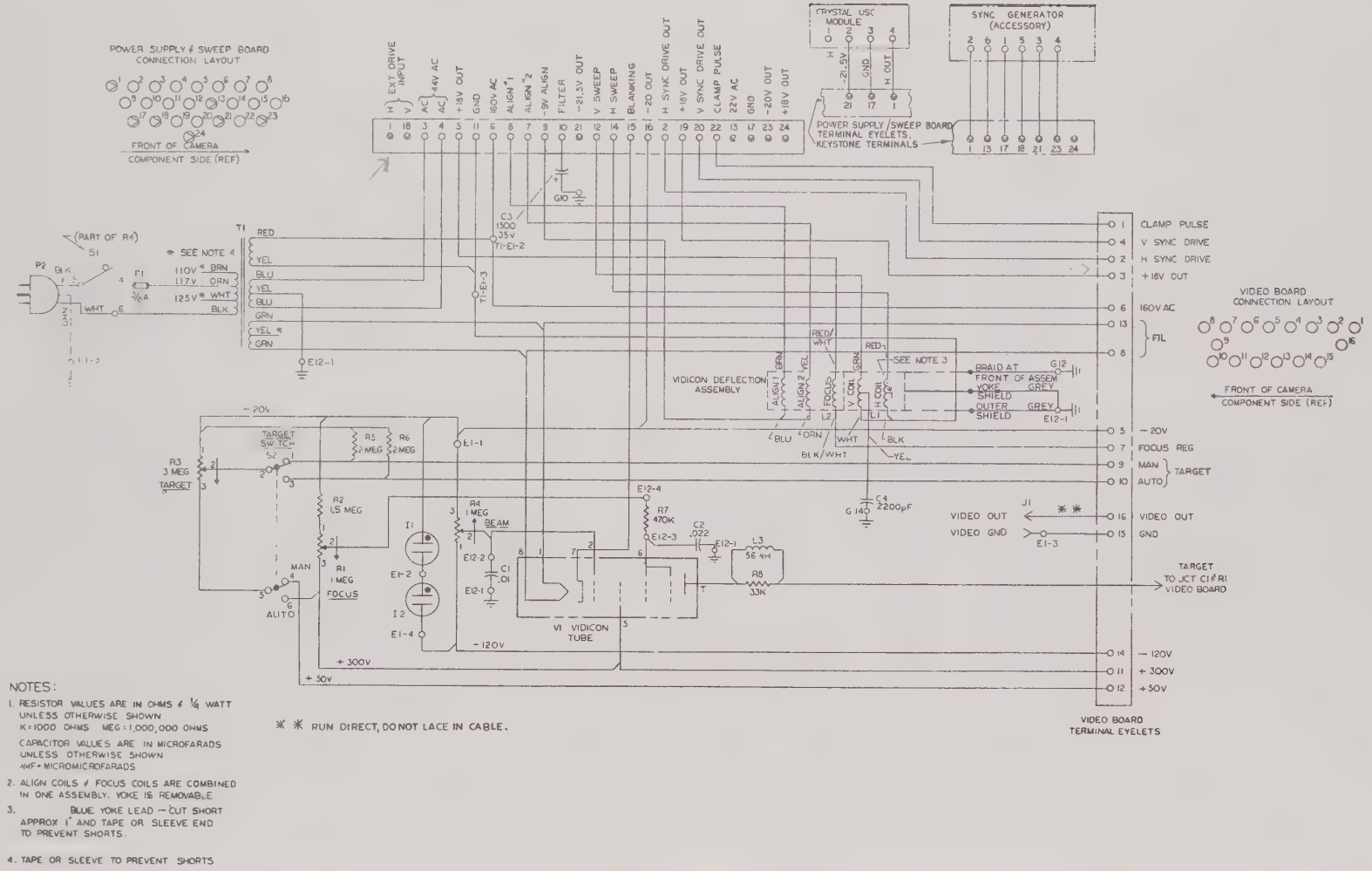


Fig. 17 Video Board Schematic Diagram (DD-7673873, Sheet 2, Rev. E)



NOTES:

1. RESISTOR VALUES ARE IN OHMS & ½ WATT UNLESS OTHERWISE SHOWN
   K = 1000 OHMS MEG = 1,000,000 OHMS
   CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SHOWN
   MMF = MICROMICROFARADS
2. ALIGN COILS & FOCUS COILS ARE COMBINED IN ONE ASSEMBLY. YOKE IS REMOVABLE
3. BLUE YOKE LEAD — CUT SHORT APPROX 1" AND TAPE OR SLEEVE END TO PREVENT SHORTS.
4. TAPE OR SLEEVE TO PREVENT SHORTS

** RUN DIRECT, DO NOT LACE IN CABLE.

Fig. 18 Camera Schematic Diagram (D-7673875, Rev. N)

EBI-6136A

INSTRUCTIONS

FUNDAMENTALS OF TELEVISION AND ESSENTIALS OF OPTICS

EBI—3711

VISUAL COMMUNICATION PRODUCTS DEPARTMENT
CONSUMER ELECTRONICS DIVISION

GENERAL ELECTRIC

ELECTRONICS PARK, SYRACUSE, N. Y.

5/67 (2M)

CONTENTS

	Page
Fundamentals of Television	1
Essentials of Optics	3

ILLUSTRATIONS

Fig. 1	Block Diagram, Closed Circuit Television System	1
Fig. 2	Simple Non-Interlace Scanning Principle	2
Fig. 3	Interlaced Scanning Principle	2
Fig. 4	Sawtooth Yoke Current	3
Fig. 5	Video Signal of One Horizontal Line	3
Fig. 6	Subject Width vs. Subject Distance for 0.5-Inch, 1.0-Inch and 3-Inch Lenses	5
Fig. 7	Subject Width vs. Subject Distance for 3-Inch, 6-Inch, and 9-Inch Lenses	5

FUNDAMENTALS OF TELEVISION

The followng is a brief discussion of how a closed circuit television system functions. A closed circuit system is similar to the standard television broadcast system except that the picture information is transmitted to the picture screen by means of a coaxial cable instead of through space.

In a television system the first requirement is to generate an electrical equivalent of an illuminated subject or scene. See the Block Diagram, Closed Circuit Television System, Fig. 1.

The scene to be televised is focused, by means of a suitable lens, on the photoconductive-layer surface of the camera pickup tube. The resulting image is scanned by an electron beam in the camera tube, the amount of light the beam encounters at any instant determining the camera tube current. As a result of the camera tube scanning process, an output voltage proportional to the light intensity is obtained. The output voltage thus generated is called the video signal.

The video signal is amplified (strengthened) by video amplifiers in the Camera and applied to the Monitor, where it is converted from electrical to visual form, appearing on the Monitor screen as a picture.

In order for the Camera and Monitor circuits to work together (in synchronism), a synchronizing generator is included in the system. It generates pulses of electrical energy which are applied to both the Camera and the Monitor. The pulses from the synchronizing generator lock together the scanning beams in the Camera and the Monitor.

Camera Pickup Tube

The camera pickup tube used in a closed circuit monochrome camera is called a vidicon tube. In television broadcasting studios, larger pickup tubes with somewhat greater light sensitivity are used, but the size of the cameras and the cost of the tubes make their use impractical in an industrial television system, where maximum convenience and minimum maintenance costs are important.

Scanning System

The electron beam in the camera pickup tube, scans or sweeps across the image in an orderly fashion. In effect it divides the image into narrow horizontal strips, called lines. The beam scans each line from left to right, producing a video signal for each line, of which there are 525. In the Monitor,

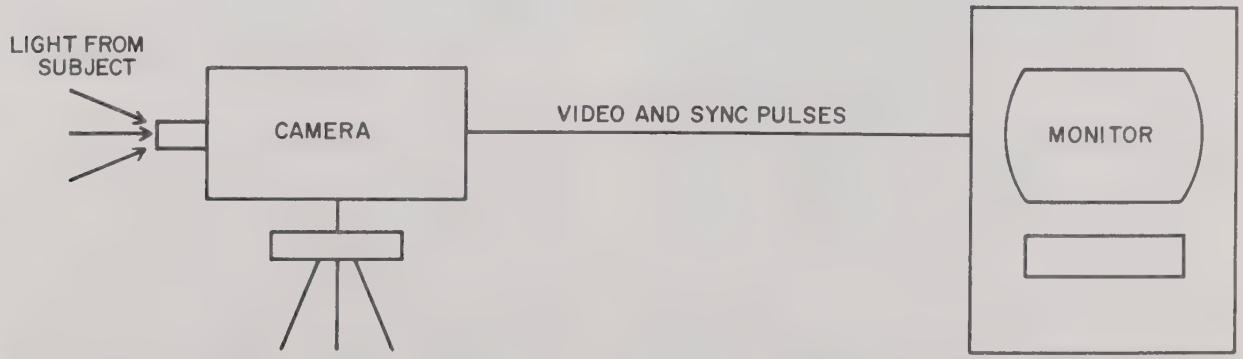


Fig. 1 Block Diagram, Closed Circuit Television System

the scanned lines are reassembled on the face of the picture tube in proper order. Fig. 2 illustrates the basic scanning principle. The scanning beam starts at the top left of the image and moves to the right and slightly downward at a uniform rate. When it reaches the end of the first line, it switches rapidly

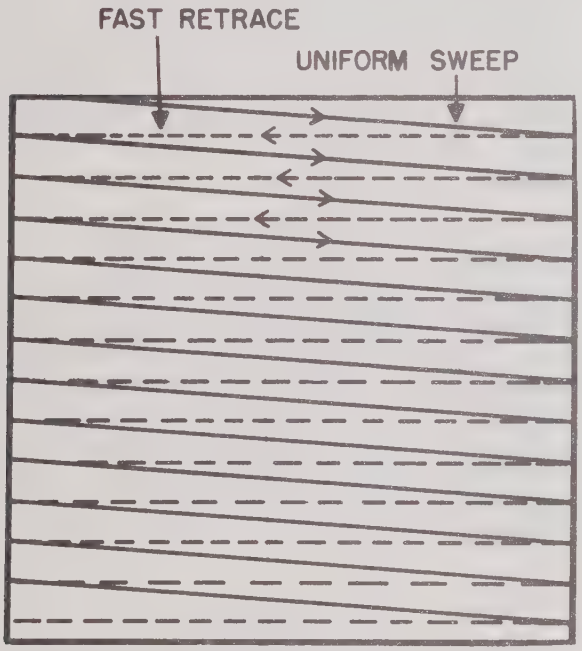


Fig. 2 Simple Non-Interlace Scanning Principle

back to the beginning of the second line. This fast return of the beam between each scanned line is called the retrace period. When the beam has scanned all of the horizontal lines and reaches the bottom of the image, it is rapidly returned to the top and the scanning process is repeated. The beam scans the image so rapidly that to the eye, no motion is apparent, and the lines blend into a complete picture. Note that no video signal is produced during the retrace period; in fact, in some monitors the picture tube beam is actually turned off during retrace.

The simple scanning system described above will produce a picture, but in practice a modified scanning method is used to reduce flicker. In the interlaced scanning system, the beam scans the image from left to right as before, but the horizontal lines are spaced apart by the thickness of one line. After one half of the 525 lines have been scanned, the beam is at the bottom of the image, and is returned rapidly to the top. It then scans the picture again, but the second set of lines are interlaced between the first set. The first set of horizontal lines is called the first field, while the second set is called the second field. The first field contains the first, third, fifth, seventh, and all succeeding odd numbered lines, and the second field contains the second, fourth, sixth, and all succeeding even numbered lines. Fig. 3 shows the interlaced scanning principle.

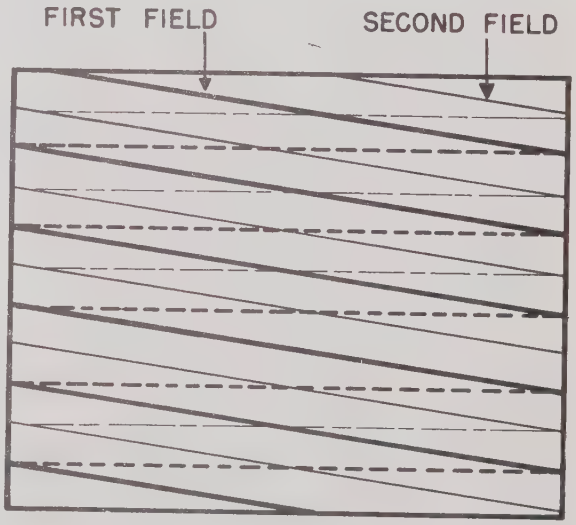


Fig. 3 Interlaced Scanning Principle

For each complete picture 525 lines are scanned ($262\frac{1}{2}$ lines during each field), which is termed a frame. Since 30 frames per second are scanned, 525 x 30, or 15,750 lines are scanned each second.

In the camera, sawtooth shaped pulses of electrical current are caused to flow through the vertical and horizontal windings of the camera deflection yoke. When the sawtooth pulses flow through the yoke coils, magnetic fields are set up which deflect the electron scanning beam in the desired scanning pattern. The horizontal sawtooth pulses recur 15,750 times each second and move the beam from left to right. The vertical sawtooth pulses recur 60 times each second and move

the beam from top to bottom. Fig. 4 illustrates the shape of the current sawtooth pulses which flow in the deflection yoke.

The previously mentioned sawtooth pulses from the synchronizing generator occur at the time when each sawtooth current must start to flow. Circuits in the camera sawtooth generator which generate the sawtooth pulses are triggered by synchronizing pulses, thus insuring that the vertical and horizontal scanning beam motions are interlocked.

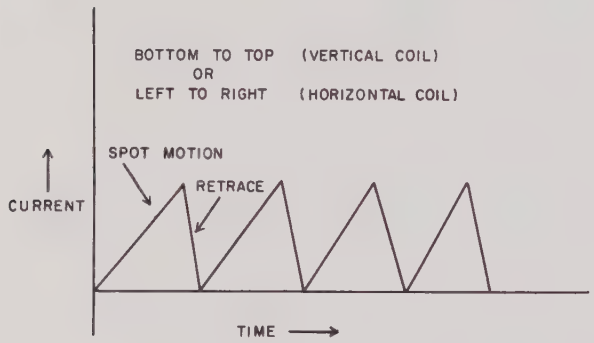


Fig. 4 Sawtooth Yoke Current

When horizontal triggering pulses are developed in a free running oscillator and vertical pulses are derived directly from the power line frequency, there is no positive interlocking of the horizontal (15,750) and vertical (60) frequencies. The difference in frequency between the oscillator and the power line may drift, over a period of time, due to small changes in oscillator and/or power line frequencies. This results in random interlace; that is; the lines of the second field may fall at random anywhere between the lines of the first field, and at times, on the lines of the first field.

The Video Signal

The video signal from the vidicon tube is amplified by video amplifiers in the Camera. Fig. 5 depicts the shape of the video output voltage. Note that the video voltage for only one of the 525 scanned lines is shown.

The output of the Camera contains only the video signal with added horizontal and vertical synchronnizing pulses. The pulses serve to keep the Monitor scanning beam in step with the Camera scanning beam, and also turn the Monitor beam off during the retrace periods.

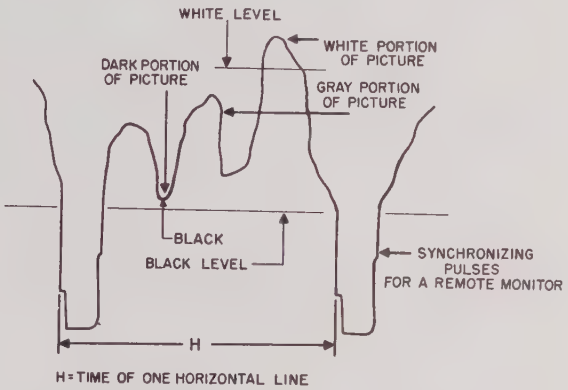


Fig. 5 Video Signal of One Horizontal Line

Monitor

The Monitor converts the electrical video signal from the video chassis into an image on the screen of its picture tube.

The picture tube has an electron scanning beam which is controlled by sawtooth pulsed currents flowing in a deflection yoke. The beam strikes the screen of the picture tube, which is coated with a fluorescent substance, and makes the coating glow. The strength of the beam is controlled by the video signal, resulting in a recreation of the original scene on the screen. Of course, the sawtooth pulses flowing in the Monitor deflection yoke are also timed by the synchronizing pulses so that the beam in the Monitor is moved in synchronism with the beam in the Camera.

ESSENTIALS OF OPTICS

The camera lens is used primarily to focus an image of a desired scene on the photosensitive surface of the camera pickup tube.

Two basic characteristics of a camera lens are the focal length and the lens speed designation. The focal length is the distance from

the optical center of the lens to the point behind the lens where the scene is focused. Therefore, if an object at infinity is focused at a point two inches behind the lens, the focal length (F.L.) is two inches. Usually, the greater the F.L. the greater the physical length of the lens barrel.

The focal length governs the image magnification and the angle of field covered. Longer F.L. lenses make distant objects appear "close-up", thus enlarging the produced image. When longer focal length lenses are used, the field of coverage is less. When the subject to be reproduced is larger than the field of view of the lens, either the subject or the camera will have to be moved back, or a shorter focal length lens used to obtain a greater angle.

Horizontal and vertical field coverage for a given F.L. lens has a direct relation to the scanned area of the photoconductive surface upon which the image is focused. Refer to the ratios below.

$$\frac{\text{F.L.}}{\text{Scanned Area Width}} = \frac{\text{Distance of Subject From Lens (feet)}}{\text{Width of field (feet)}}$$

The standard television aspect ratio is three units high and four units wide, and the scanned area of the light sensitive element of the vidicon is 3/8 inch high by $\frac{1}{2}$ inch wide to correspond to this ratio. Therefore, since the vidicon scanned area width equals $\frac{1}{2}$ inch, the above equation can be written as follows:

$$W = \frac{0.5 \times D}{\text{F.L.}}$$

where W = Width of field (feet).
D = Distance of subject from lens (feet).
F.L. = Focal length (inches).

The height of field (feet) viewed by the lens will be:

$$H = 3/4 \times \text{width of field}$$

The following examples will show how the above equations may be used.

EXAMPLE 1

The camera is equipped with a one-inch focal length lens and the scene to be viewed is located 20 feet from the camera. What area will be viewed by the camera?

$$W = \frac{0.5 \times D}{\text{F.L.}} = \frac{0.5 \times 20}{1} = 10 \text{ feet}$$

$$H = 3/4 \times W = 3/4 \times 10 = 7.5 \text{ feet}$$

As shown, the camera will view an area 10 feet wide and 7.5 feet high.

The same formula can be used to determine the necessary distance from the camera to a scene of a given width to be viewed. Using the above equation.

$$D = \frac{W \times \text{F.L.}}{0.5} = \frac{10 \times 1}{0.5} = 20 \text{ feet}$$

EXAMPLE 2

A scene 30 feet wide is to be viewed with a camera having a 0.5-inch F.L. lens. What is the distance from the scene to the camera?

$$D = \frac{W \times \text{F.L.}}{0.5} = \frac{30 \times 0.5}{0.5} = 30 \text{ feet}$$

EXAMPLE 3

The following example will show how the F.L. of a lens may be determined.

A scene to be viewed is 20 feet wide, but the camera cannot be located more than 30 feet from the scene. What F.L. lens is required?

$$\text{F.L.} = \frac{0.5 \times D}{W} = \frac{0.5 \times 30}{20} = 0.75 \text{ inch}$$

If a 0.75-inch lens is not available, the next smaller size, which is a 0.5-inch F.L. lens, will have to be used. At a distance of 30 feet the 0.5-inch lens will actually view a width of 30 feet, as obtained from the equation below.

$$W = \frac{0.5 \times 30}{0.5} = 30 \text{ feet}$$

Since it is only necessary to view 20 feet of the scene width, the distance from the camera to the scene will be

$$D = \frac{W \times \text{F.L.}}{0.5} = \frac{20 \times 0.5}{0.5} = 20 \text{ feet}$$

Therefore, the camera should be located 20 feet from the scene being viewed, and equipped with a 0.5-inch F.L. lens.

The above mentioned examples may be solved at a glance by using the Subject Width vs. Subject Distance charts, Figs. 6 and 7. When using the charts be sure the F.L. of the lens corresponds to the F.L. of the chart being used.

To solve the examples using the charts, proceed as follows.

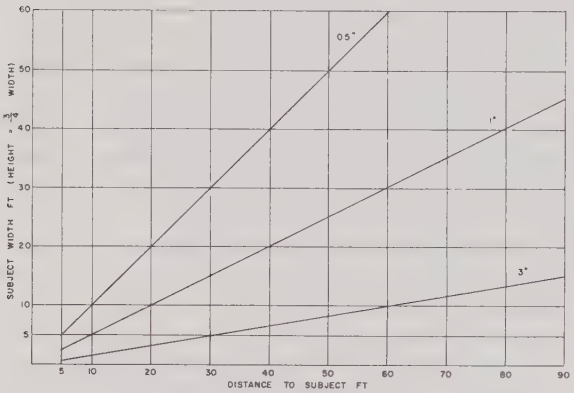


Fig. 6 Subject Width vs. Subject Distance for 0.5-Inch, 1.0-Inch, and 3-Inch Lenses

EXAMPLE 1

Locate the intersection of the one-inch lens line and the 20-foot distance line. Extend this point horizontally until it intersects with the Subject Width axis. As shown on the chart, the width is 10 feet. The height is 3/4 x 10 or 7.5 feet.

EXAMPLE 2

To determine D, locate the intersection of the 30-foot width line and the 0.5-inch F.L. lens line. Drop this line down to the distance axis. As shown, the distance is 30 feet.

EXAMPLE 3

Locate the intersection of the 20-foot width line and the 30-foot distance line. This point lies half-way between the one-inch lens line and the 0.5-inch lens line. Therefore, the 0.5-inch lens must be used. As shown in Fig. 6, a 0.5-inch F.L. lens views an area 30 feet wide. If an area 20 feet wide is to be viewed using a 0.5-inch lens, the distance from the camera to the scene being viewed is 20 feet.

The lens manufacturer normally supplies a booklet with each lens. This booklet contains a data chart which gives the height and width of the area covered by the lens at various distance settings.

The focal length of some lenses may be stated in millimeters (mm). The above mentioned equations and charts are applicable only when the F.L. is expressed in inches. One inch is equal to 25.4 mm, therefore to convert mm to inches use the equation below.

$$\frac{\text{millimeters}}{25.4} = \text{inches}$$

For example, a 50 mm F.L. lens is equal to $\frac{50}{25.4}$ inches, or approximately a two-inch F.L. lens.

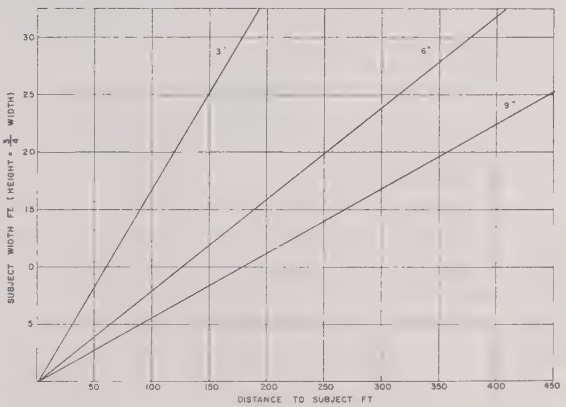


Fig. 7 Subject Width vs. Subject Distance for 3-Inch, 6-Inch, and 9-Inch Lenses

The second lens characteristic is lens speed designation. More light will be transmitted by a lens when the effective lens diameter is increased and the lens designation is decreased. Most lenses have an adjustable iris so that the effective diameter of the lens can be controlled. The lens iris performs the same function as the iris of the human eye. When the eye suddenly sees a bright scene, the iris automatically closes to admit less light, thereby preventing temporary blindness. In a television system the camera tube operates over a limited range of brightness. Any sudden increase of light may cause the camera tube to become inoperative since the lens iris is not an automatic device (unless

the camera is equipped with an Automatic Iris Control); therefore, the lens iris must be adjusted manually.

As mentioned above, the lens speed designation is a function of the F.L. and may be calculated by the following equation.

$$\text{Lens speed designation (f)} = \frac{\text{F.L.}}{\text{D}}$$

Where F.L. = Focal length of lens (inches)
D = Lens diameter with the iris at its widest opening (inches).

For example, a one-inch lens that has an iris opening of 0.66 inch will have a lens speed designation of 1.5 as shown in the equation below.

$$f = \frac{1.0}{0.66} = 1.5$$

When lens speed is referred to, one lens is said to be "faster" or "slower" than another lens. The "faster" lens will have a lower lens speed designation or f number, and will pass more light (iris opening of the "faster" lens is larger). THE f NUMBER OF A LENS INCREASES AS THE IRIS DIAMETER IS DECREASED.

For example, compare the light passing capabilities of two lenses, or two f numbers on the same lens, such as f1.5 and f3.0. The f1.5 lens will admit more light than the f3.0 lens. Actually the amount of light varies inversely as the square of the f number ratio. In this example the f3.0 lens will pass $\left(\frac{\text{f1.5}}{\text{f3.0}}\right)^2$, or one quarter as much light as the f1.5 lens.

Most lenses are equipped with the following adjustments:

FOCUS RING ADJUSTMENT - Adjusts for sharpest focus, calibrated in feet.

IRIS RING ADJUSTMENT - Adjusts iris diameter, calibrated in f numbers.

In general the iris is set to its widest opening (lowest f number) for low light levels, and is "stopped down" (iris closed further) when the scene illumination increases above normal. In addition to changing the amount of light passed through a lens, variations of the iris diameter will also affect the depth of field of the lens. This effect is especially noticable on scenes or objects near the camera. A certain portion of the scene will be in focus. However, objects nearer to and farther away from the camera will be out of focus. The depth of field pertains to the portion of the scene that is in focus, and is measured by the distance from the nearest to the farthest points in focus. The factors which affect the depth of field are:

FOCAL LENGTH - Depth of field increases with shorter focal length lenses.

f STOP NUMBERS - Depth of field increases as the f number increases.

DISTANCE FROM LENS TO OBJECT IN FOCUS - Greater distances will result in greater depth of field.

The depth of field varies with the f number, focal length, and certain design characteristics of the lens (such as telephoto and wide-angle). The manufactures's booklet supplied with the lens contains data tables which give the depth of field for various combinations of f numbers and focus distance. Some lenses have a depth of field scale built into the lens mounting. This shows the approximate depth of field at all distances and f number stops.

INSTRUCTIONS

FUNDAMENTALS OF THE VIDICON TUBE AND TRANSISTOR CHARACTERISTICS

EBI—3781A

VISUAL COMMUNICATION PRODUCTS DEPARTMENT
CONSUMER ELECTRONICS DIVISION

GENERAL ELECTRIC

ELECTRONICS PARK, SYRACUSE, N. Y.

5/67 (2M)

PRINTED IN U.S.A.

CONTENTS

Page

Fundamentals of the Vidicon Tube. 1
Transistor Characteristics. 3

DRAWINGS

Fig. 1 Vidicon Defects Resulting from Improper Handling 2
Fig. 2 NPN and PNP Transistors Compared to the Vacuum Tube 4

INSERT

Vidicon Tube Bulletin

FUNDAMENTALS OF THE VIDICON TUBE

The structural arrangement of and additional information about the vidicon tube can be found in the Vidicon Tube Bulletin, located in the back of this book.

The photoconductive layer of the vidicon tube is made up of many small elements, each of which is essentially an insulator in the dark, but conductive when illuminated. The target (signal electrode) ring makes contact with the front side of the layer and is maintained at a positive potential. A beam of electrons from the vidicon electron gun (cathode and grids #2, #3, and #4) scans the rear side of the layer, and the scene to be televised is focused on the front. Since the amount that the photoconductive layer will conduct is dependent on the level of illumination reaching it, each element on the rear side of the layer will rise toward the positive target voltage. Thus, a positive voltage pattern corresponding to the focused scene is deposited on the rear side of the layer. The electron gun beam produced by the electron gun scans this voltage pattern, deposits enough electrons on the back side of the photoconductor layer, and reduces them to the vidicon cathode potential.

Each photoconductor element may be considered as a capacitor with one plate connected to the positive target voltage and the other plate grounded. Each plate contains internal resistance proportional to the amount of illumination striking it. Since the two sides of the photoconductive layer are connected by the external target circuit and the electron beam, a capacitive video signal current is produced. Increasing or decreasing the target voltage or the illumination of the vidicon tube will cause a corresponding increase or decrease in the video output signal from the vidicon tube.

The TARGET control can be considered as a sensitivity or gain control for the vidicon tube and will affect the output. With a given light level, increasing the target potential (clockwise rotation) will increase the output. However, there is a limitation in the extent the target voltage can be increased. If the target voltage is increased excessively, a bright ring will appear around the outer edges of the photoconductive layer. As the photoconductive layer is not a perfect insulator in the dark, a small amount of dark or leakage current will occur. The dark current is greater around the circumference of the photoconductive layer than in the center and visually appears as a white ring (edge flare) around the edge. See Fig. 1(c). When the target voltage is increased, the edge flare increases, and when the target voltage is increased far enough, edge flare will be visible in the monitor picture. Therefore, a certain target control setting will represent the vidicon sensitivity with unobjectionable edge flare. This setting is called the optimum sensitivity of the target control for a particular vidicon tube.

The BEAM control varies the amount of the negative voltage on grid #1 of the vidicon tube and thus controls the strength of the electron beam. As previously stated, the television scene is represented by a positive voltage pattern, the higher illuminated portions being more positive. Therefore, sufficient electrons must be supplied to discharge (reduce to ground potential) the highest illuminated parts of the photoconductive layer. If the strength of the electron beam is increased excessively beyond this point, distortion of the picture will result. Too little beam current will result in loss of detail in the more highly illuminated areas of the scene being viewed.

A characteristic of the vidicon tube is its tendency to retain the image of a subject when either the Camera or subject moves. When this occurs, the image of the subject appears blurred (as seen on the monitor screen). This characteristic can be decreased by increasing the illumination on the sub-

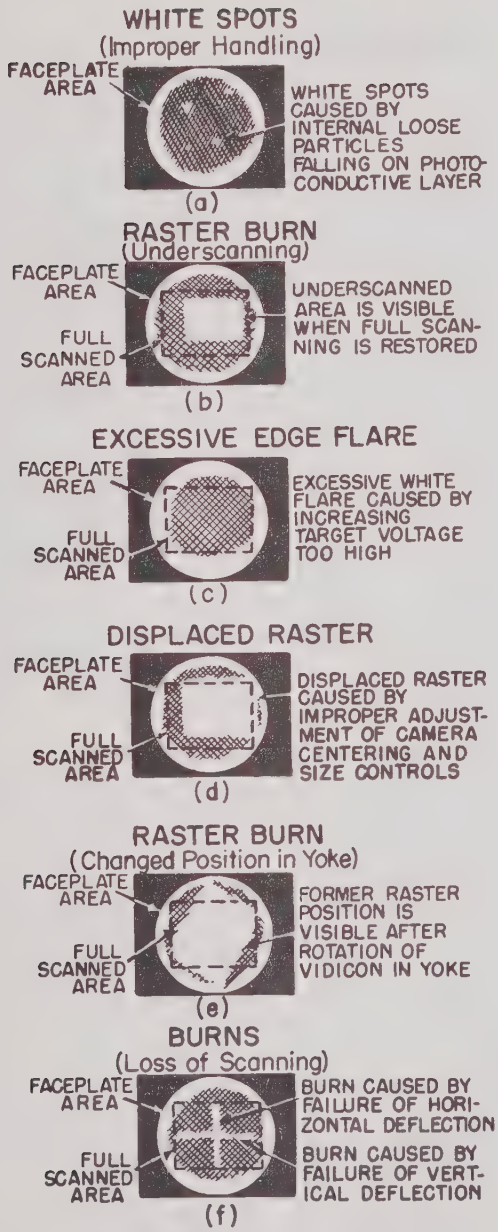


Fig. 1 Vidicon Defects Resulting from Improper Handling

ject. The vidicon photoconductive layer is deposited on the circular faceplate of the tube. The diameter of this layer is 3/4 inch. However, the useful scanning area of the photoconductive layer is a rectangle 3/8 x 1/2 inch. If an area greater than or displaced from the 3/8 x 1/2 inch rectangle is scanned, the tube is operating outside its specified limits. Scanning an area less than the 3/8 x 1/2 inch quality area (underscanning) will generally result in pictures of reduced resolution as well as possible tube damage. Underscanning should be avoided at all times.

Due to the semiconductor nature of the photoconductor, certain inherent properties make it important to utilize the full 3/8 x 1/2 inch scanning area, being careful not to exceed or fall outside it. During scan, a layer conditioning takes place which results in extra sensitizing of the scanned area. This extra sensitizing is commonly referred to as raster burn, a normal characteristic of vidicon tubes. Raster burn appears on the monitor screen as a light-toned area. Thus, if too small an area is scanned initially and a larger area is scanned later, the smaller underscanned area will appear light and framed within the larger scanned area.

Similarly, if after initial use the vidicon tube is rotated, use in the new position will reveal a raster burn at an angle to horizontal.

Overscanning is not harmful to the tube, but since it involves an area larger than the rectangular 3/8 x 1/2 inch quality area, it may result in a picture showing edge flare and/or blemishes outside the quality area.

The correct procedure for obtaining the 3/8 x 1/2 inch quality area on the photoconductive layer of the tube is outlined in the Camera and Sweep Adjustments section under MAINTENANCE in the Camera instruction book. After the quality area is obtained, further adjustment of the Camera controls (size, centering, alignment), should be avoided. If the position of the tube is changed, a raster burn may result. Refer to Fig. 1(e). Therefore, changing the tube position should be avoided.

Vidicon Precautions

The following precautions should be observed when handling or operating the vidicon tube.

1. When handling the vidicon, always keep it in a horizontal or vertical position with the faceplate up.

2. Adjust the Camera scanning to utilize the maximum useful area of the photoconductive layer.

3. Match any visible raster pattern on the photoconductive layer with new scan.

4. Align the electron beam.
5. With the lens capped, adjust the target voltage for each individual vidicon to the highest value that will still give a uniform background.
6. Open the lens iris or increase the scene illumination to obtain the snappiest picture without noticeable smear from moving objects.
7. Use only sufficient beam current to bring out picture highlights.
8. Always cap the lens when transporting the Camera.

CAUTION

NEVER ALLOW AN IMAGE OF THE SUN TO BE FOCUSED ON THE PHOTOCONDUCTIVE LAYER AT ANY TIME.

9. Never operate or transport the Camera with the faceplate in the down position, unless a vidicon with a particle shield such as the 7226 or 7262A is being used. Refer to Fig. 1(a).
10. Never underscan the photoconductive layer. Refer to Fig. 1(b).
11. Never change the Camera size and centering controls once the scanned area of the photoconductive layer has been properly positioned. Refer to Fig. 1(d).
12. Never rotate the vidicon from its original operating position in the deflecting yoke. Refer to Fig. 1(e).
13. Never turn the beam or the vidicon on without normal scanning. Refer to Fig. 1(f).

TRANSISTOR CHARACTERISTICS

The most common semiconductor devices, and those to be found in General Electric Closed Circuit equipment, are diodes, transistor triodes, and transistor tetrodes. All may be constructed of the two most used semiconductor materials, germanium and silicon.

While comparisons between semiconductor devices and vacuum tubes result in useful analogies, these should not be carried too far, since transistors have many characteristics which have no counterpart in vacuum tube technology.

The major advantages of transistors over vacuum tubes are their small size, mechanical rigidity, and very modest power requirements.

A comparison of vacuum tubes and junction transistors reveals one of the most significant differences. The impedances in transistor circuits are much lower than in vacuum tube circuits. That is to say, transistors are current operated rather than voltage operated. The transistor electrode most analogous to the tube control grid (the base) draws measurable current from its bias and signal sources. Because of this characteristic, the design of transistor circuits requires a new approach.

In addition, two general types of transistors are available: NPN and PNP. See Fig. 2.

Note the comparison between the base and grid, emitter and cathode, and collector and plate. Also of note is that the NPN transistor requires a positive potential on its collector as does the vacuum tube on its plate. Since the PNP transistor requires a negative collector potential, no direct vacuum tube analogy exists, although the base, emitter, and collector functions remain analogous.

For a complete introduction to transistors and circuits, it is recommended that a copy of the General Electric Transistor Manual (latest edition) be purchased from a General Electric tube and transistor dealer.

Trouble Shooting

The trouble shooting techniques in this book are applicable to all General Electric Closed Circuit Television transistorized equipment.

Elementary Diagrams in the respective instruction books are representive of major sections, and therefore will facilitate trouble shooting.

With the help of the Elementary Diagrams, oscilloscope waveforms, d-c socket voltages, and trouble shooting charts, it should be

possible to locate the more common faults which can occur.

Note that localization of faults does not differ from vacuum tube equipment of similar nature.

A few differences between vacuum tube and transistor circuits, which may prove valuable to know, follow.

Vacuum tubes generally operate with plate potentials in the range of 100 to 300 volts. Transistor collector potential ranges from two or three volts to 50 volts.

The control grid in a Class A vacuum tube circuit is several volts removed from the cathode. However, in a Class A transistor stage, the base and emitter will be about 0.2 volt apart (germanium) and about 0.6 volt apart (silicon). Note, however, that in some circuits in the equipment the transistors are used as switches and the base is not necessarily clamped to the emitter in this way.

Since transistors operate with such small voltage differences between terminals, it becomes important to search for smaller voltage errors when trouble shooting transistor stages than experience with tubes would indicate.

When using an oscilloscope for waveform analysis, it is seldom necessary to use a high impedance probe, since the impedance level in transistor circuits is relatively low.

It is most important to guard against accidental shorting of components with screwdrivers, 'scope leads etc., in transistorized equipment because semiconductor devices are easily and permanently damaged by momentary application of incorrect potentials.

Testing Transistors

Transistors are more easily ruined than vacuum tubes by improper testing or by the application of improper potentials in a faulty circuit. For this reason it is recommended that the following suggestions be carefully heeded.

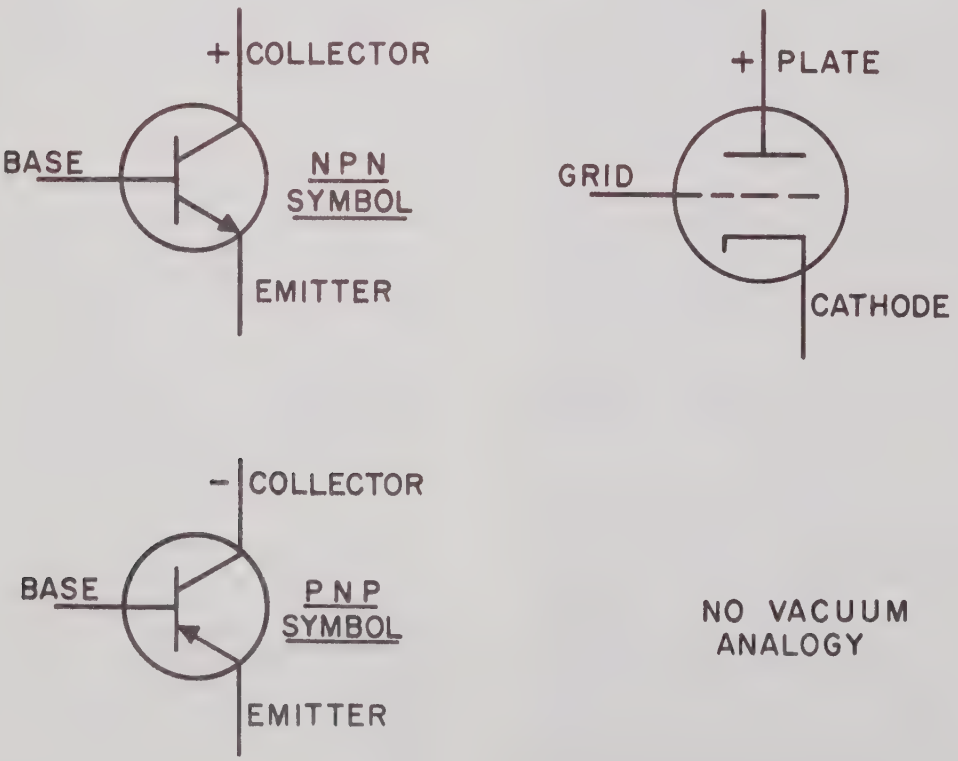


Fig. 2 NPN and PNP Transistors Compared to the Vacuum Tube

In general, it is inadvisable to attempt transistor checking with an ohmmeter, because the battery built into the meter may apply a potential to the transistor electrodes which exceeds the transistor rating.

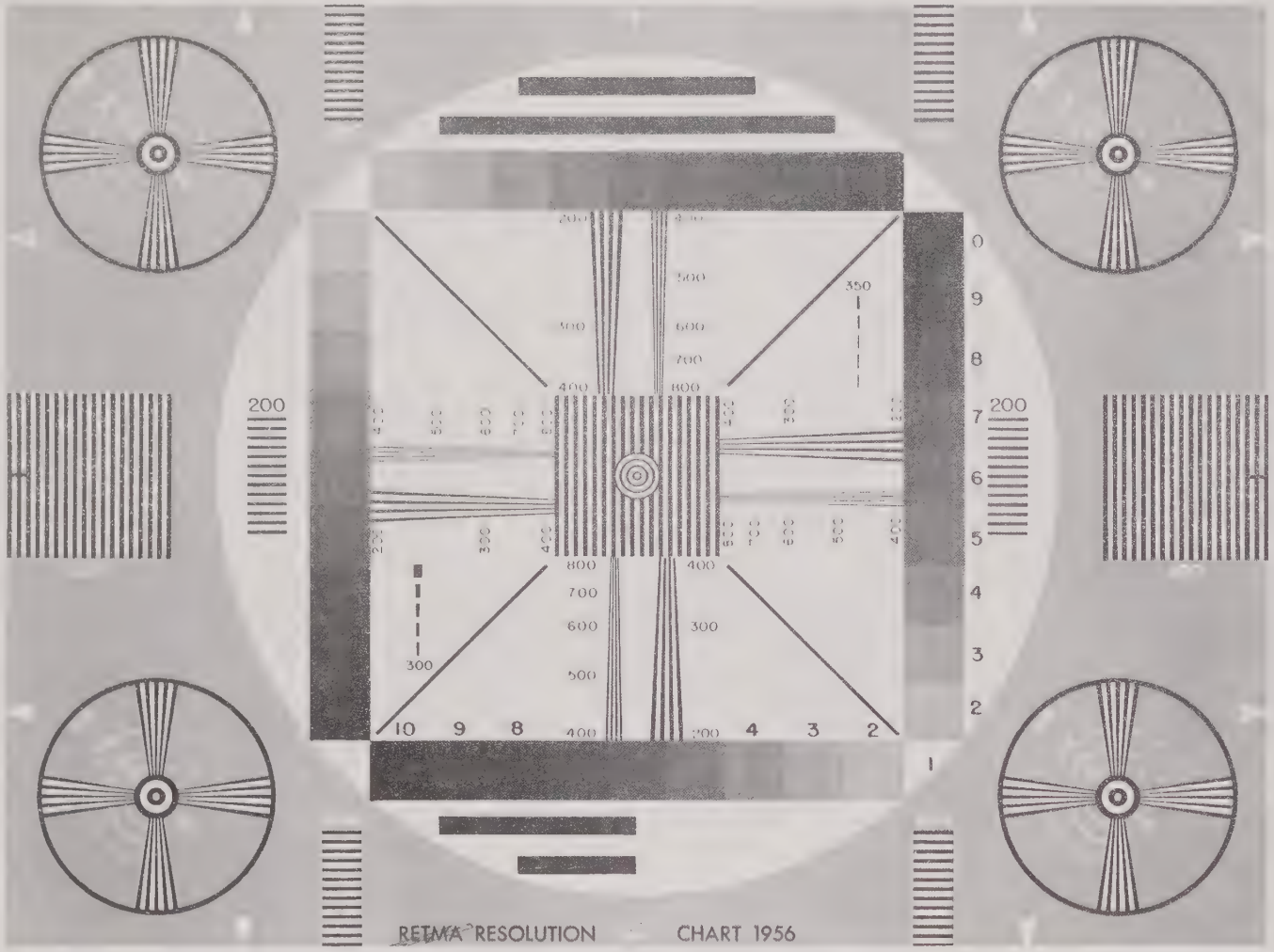
It has been found that one of the most important characteristics of a transistor is the a-c current gain, designated h_{fe}, or beta. Beta applies when a transistor is connected in the common emitter configuration.

Another characteristic is known as base-collector leakage current, designated I_{co}. I_{co} should be as small as possible and is a measure of transistor quality. Beta and I_{co} vary with different transistor electrode potentials which makes it advisable to check a transistor with the collector voltage, collector current, and base current which prevail in the circuit in which it is to be used.

A commercial transistor checker is a wise investment if transistorized equipment is to be maintained, particularly if rapid trouble shooting is required. This is not to imply that transistors are not reliable or that they have short life under normal conditions. Normally transistors have a much longer life than vacuum tubes. However, a faulty circuit component or a power supply voltage out of specifications can cause application of potentials to a transistor which could cause its untimely demise.

A transistor checker may be simple or refined, but even the simplest is useful and indicates beta and I_{co}. An example of a simple checker is the Triplett Model 690A. Another unit, the Armour Electronics Model T-340 is an example of the more refined checker.

For additional information on transistors, their theory, application, and characteristics, refer to the General Electric Transistor Manual (Seventh Ed. 652 pages) available for $2.00 from most G. E. Authorized distributors and dealers, or from the General Electric Co., 1 River Road, Schenectady, New York.



RETMA Resolution Chart

PRODUCTION CHANGE SHEET

LOCAL-CONTROL CLOSED CIRCUIT TELEVISION CAMERA MODEL 4TE20A1

REVISION A

Parts List and Schematic Diagram, Fig. 18.

Symbol	Was	Changed To
C3	Electrolytic, 500 mfd +150%, -20%, 30 v d-c w. Illinois Condenser Cat. #SMT-50030. GE Drawing C-7777665-P10.	Electrolytic, 1500 mfd +250% -10%. 35 v d-c w. GE Drawing C-7776308-P18.
C4	Same as C3 and connected in parallel with it.	Not used.

Power Supply/Sweep Board: Parts List and Schematic Diagram, Fig. 15

Symbol	Was	Changed To
2Q5	Delco Type 2N553.	Motorola Type 2N3614.
2C16	Electrolytic; 500 mfd +150% -20%, 30 v d-c w. Illinois Condenser Cat. #SMT-50030. GE Drawing C-7777665-P10.	500 mfd +150% -20%, 30 v d-c w. Mallory Type #TCW. GE Drawing C-7775849-P18.
2C23	Electrolytic; 400 mfd +150% -20%, 6 v d-c w. Illinois Condenser Cat. #SMT-4006. GE Drawing C-7777665-P12.	300 mfd +75% -10%, 6 v d-c w. Sprague Cat. #30D139A1. GE Drawing B-7489483-P24.
2CR5	Silicon rectifier; 200 PIV max. EIA Type #1N3193. GE Drawing B-7493633-P1.	Silicon rectifier, 25 PIV. GE Drawing A-7164424-P144.
2CR6 and 2CR7	Silicon rectifiers; 200 PIV max. EIA Type #1N3193. GE Drawing B-7493633-P1.	Silicon rectifiers; 150 PIV. GE Drawing A-7164424-P145.

Symbol	Was	Changed To
2CR8 and 2CR9	Silicon rectifiers; GE Type #1N2611. GE Drawing A-7164424-P102.	Silicon rectifiers; 150 PIV. GE Drawing A-7164424-P145.
2CR10	Silicon rectifier; 200 PIV max. EIA Type #1N3193. GE Drawing B-7493633-P1.	Silicon rectifier; 25 PIV. GE Drawing A-7164424-P144.
2CR11	Zener diode. U.S. Semcor Type #1N1819A or Type #1N1357A. GE Drawing A-7164424-P61.	Zener diode; 18 v ± 10%, 10 w. GE Drawing A-7164424-P148.
2CR12	Zener diode; 15 v ± 10%. Transitron Type #1N767. GE Drawing A-7166198-P7.	Zener diode; 15 v ± 10%, 1 w. GE Drawing A-7164424-P147.

Video Board: Parts List and Schematic Diagram, Fig. 17

Symbol	Was	Changed To
3Q2 thru 3Q4, 3Q6	Sprague Type 2N502A.	Sprague Type 2N2048.
3CR1 thru 3CR4	Silicon rectifiers; 600 PIV max. EIA Type #1N3195. GE Drawing B-7493633-P3.	Silicon rectifiers; 600 PIV. GE Drawing A-7164424-P143.
3CR6 and 3CR7	Zener diodes; 150 v ± 10%. Transitron Type #$\frac{1}{4}$M150Z. GE Drawing A-7166198-P10.	Zener diodes; 150 v ± 5%, 1 w. GE Drawing A-7172767-P148.
3CR8	Zener diode; 5.6 v ± 10%. Transitron Type #1N762. GE Drawing A-7166198-P2.	Zener diode. Hughes Type #1N752A. GE Drawing A-7164424-P90.
3CR9 thru 3CR12	Silicon rectifiers. GE Type #1N2611. GE Drawing A-7164424-P102.	Silicon rectifiers; 25 PIV. GE Drawing A-7164424-P144.

PRODUCTION CHANGE NO. 1

LOCAL-CONTROL CLOSED CIRCUIT TELEVISION CAMERA MODEL 4TE20A1, REVISION A

AUTHORIZATION: GE-34113, -34114, -34117, -34122

Camera (Back Plate): Parts List and Schematic Diagram, Fig. 18

Symbol	Was	Changed To
F1	Fuse, cartridge type; 3/4 amp at 250 v. GE Drawing 1R16P2.	Fuse, cartridge type; 3/8 amp at 250 v. GE Drawing 1R16P14.

Power Supply/Sweep Board: Parts List and Schematic Diagram, Fig. 15

Symbol	Was	Changed To
2C16	Electrolytic, tubular; 500 mfd +150% -20%, 30 v d-c w. GE Drawing C-7775849-P18.	Electrolytic, tubular; 630 mfd +75% -10%, 40 v d-c w. GE Drawing C-7775849-P174.
2R47	Composition; 39,000 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing C-3R152-P393J.	Composition; 27,000 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing C-3R152-P273J
2R48	Composition, 1600 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing C-3R152-P162J.	Not used.

Video Board: Parts List and Schematic Diagram, Fig. 17

Symbol	Was	Changed To
3C6	Electrolytic, tubular; 16 mfd +50% -10%, 250 v d-c w. GE Drawing C-7775849-P17.	Electrolytic, tubular; 20 mfd +50% -10%, 300 v d-c w. GE Drawing, C-7775849-P173.
3C33 and 3C34	Electrolytic, tubular; 2.0 mfd +50% -10%, 450 v d-c w. GE Drawing C-7774786-P47.	Electrolytic, tubular; 2.0 mfd +50% -10%, 475 v d-c w. GE Drawing C-7774786-P48.

PRODUCTION CHANGE NO. 2

LOCAL-CONTROL CLOSED CIRCUIT TELEVISION CAMERA MODEL 4TE20A1, REVISION A

AUTHORIZATION: GE-34140, -34145
SERIAL NO.: See below.

Camera (Main Assembly): Parts List and Schematic Diagram, Fig. 18

Symbol	Was	Changed To	Effective Serial No.
C2	Ceramic, Hi-K disk; 0.1 mfd +80% -25%, 500 v d-c w. GE Drawing B-7488160-P3.	Metallized mylar; 0.022 mfd ± 20%, 1000 v d-c w. GE Drawing B-7493817-P11.	1830
C4	Not used.	Silver mica, epoxy dipped; 2200 mfd ± 5%, 500 v d-c w. GE Drawing B-7496932-P16. Added between vertical deflection coil center winding (yellow lead) and ground.	1660

Power Supply/Sweep Board: Parts List

Symbol	Was	Changed To	
2L1	Variable; 500 uh min, 1000 uh max inductance, 19.8 ohms max d-c resistance per winding. North Hills Type #PF120J. GE Drawing B-7491855-P12.	Same rating, except manufacturer is Paul Smith, Inc. GE Drawing B-7399079-P1.	6001
2Q1	2N396A	2N3638	4TE20A1AY and 4TE20A1TY only

PRODUCTION CHANGE NO. 3

LOCAL-CONTROL CLOSED CIRCUIT TELEVISION CAMERA MODEL 4TE20A2

AUTHORIZATION: GE-34210
EFFECTIVE DATE: 7/11/68

Crystal Oscillator Board: Parts List and Schematic Diagram, Fig. 13.

Symbol	Was	Changed To
C3	Silver mica, epoxy dipped; 1000 pf ± 5%, 500 v d-c w. Electromotive Type DM15. GE Drawing B-7496932-P8.	Silver mica, epoxy dipped; 430 pf ± 5%, 500 v d-c w. Electromotive Type DM15. GE Drawing B-7496932-P26.
R9	Precision; 12.1 ohms ± 1%, $\frac{1}{4}$ w. GE Drawing C-3R155-P12R1.	Precision; 30.1K ohms ± 1%, $\frac{1}{4}$ w. GE Drawing C-3R166-P3012.

EBI 6136A
Model 4TE20A2
Authorization GE-34210

PRODUCTION CHANGE NO. 4

Parts List 7799576G1 Crystal Oscillator Board (P. 33, 34)

Schematic 7799577 (Fig. 13)

Symbol No.

	Changed From	Changed To
C3	Silver mica, epoxy dipped; 1000 pf ±5%, 500 v d-c w. Electromotive type DM15 GE drawing 7496932P8	430 pf. GE drawing 7496932P26
R9	Precision; 12.1 K ohms ±1% 1/4 W GE drawing 3R166P1212	30.1 K ohms GE drawing 3R166P3012

R1 (68 K) connected between Q1 base and collector instead of to ground.

Effective date of change 7/11/68

INSTRUCTIONS

SYNC GENERATOR MODULE

PL-7673939G1

EBI-6138A

CLOSED CIRCUIT TELEVISION BUSINESS SECTION
VISUAL COMMUNICATION PRODUCTS DEPARTMENT
CONSUMER ELECTRONICS DIVISION
GENERAL ELECTRIC
ELECTRONICS PARK, SYRACUSE, N. Y.

12/68 (100)

PRINTED IN U.S.A.

CONTENTS

	Page
Introduction	1
Equipment	1
Technical Summary	1
Description	2
Installation	2
Operation	4
Theory and Circuit Analysis	5
Maintenance	6
Parts List	8

DRAWINGS

Fig. 1 Installation Drawing, Sync Generator Module in TE-20-A and TE-22-A or TE-9 Series Cameras (D-7673939)
Fig. 2 TE-9 Series Interconnection Diagram, Sync Board to PX-72-A Sync Adapter (B-7497214)
Fig. 3 V Drive Pulse Width Output Waveforms
Fig. 4 Comparison, V Drive Pulse to 60-Cycle Power Line Frequency Waveform
Fig. 5 Sync Board Waveforms (a-h)
Fig. 6 Sync Board Waveforms (i-n)
Fig. 7 5:1 Counter Sawtooth
Fig. 8 7:1 Counter Sawtooth
Fig. 9 3:1 Counter Sawtooth
Fig. 10 Component Layout Drawing, Sync Board, PL-7673917G1 (D-7673917, Sheet 1)
Fig. 11 Schematic Diagram, Sync Board, PL-7673917G1 (D-7673917, Sheet 2)

PRODUCTION CHANGE NO. 1

SYNC GENERATOR MODULE
PL-7673939G1

AUTHORIZATION: GE-34016, -34045, -34113

Test and Schematic Diagram, Fig. 11

Page 2, Transistor Complement: Change 5 Type 2N526 to 4, deleting 1Q7. Add 1 Type 2N3638 (1Q7).

Page 3, TE-20-A and TE-22-A Cameras: Delete wire from sync board terminal 7 and power supply/sweep board terminal 24 from interconnection table.

Parts List and Schematic Diagram, Fig. 11

Symbol	Was	Changed To
1C17	Aluminum, electrolytic; 5 mfd +150% -20%, 25 v d-c w. GE Drawing C-7781940-P1.	Tantalum; 4.7 mfd ± 20%, 50 v d-c w. GE Drawing C-7781529-P21.
1C25	Not used.	Mylar, dielectric; 0.15 mfd ± 20%, 50 v d-c w. GE Drawing B-7496934-P7.
1R32	Composition; 22,000 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing 3R152-P223J.	Not used.
1R33	Composition; 68,000 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing 3R152-P683J.	Composition; 1300 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing 3R152-P132J.
1CR13	HD2151.	Not used.

PRODUCTION CHANGE NO. 2

SYNC GENERATOR MODULE
PL-7673939G1

AUTHORIZATION: GE-34157

SERIAL NO.: 1785

Parts List and Schematic Diagram, Fig. 11

Symbol	Was	Changed To
1R33	Composition; 1300 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing 3R152-P132J.	Composition; 4700 ohms ± 5%, $\frac{1}{4}$ w. GE Drawing 3R152-P472J.

PRODUCTION CHANGE NO. 3

SYNC GENERATOR MODULE
PL-7673939G1

AUTHORIZATION: GE-34169

Parts List and Schematic Diagram, Fig. 11

Symbol	Was	Changed To
1C1	Tantalum; 10 mfd ± 20%, 35 v d-c w. Sprague Type #167D106X0035R2. GE Drawing C-7781529-P23.	Tantalum; 10 mfd ± 20%, 35 v d-c w. GE Drawing C-7782371-P29.
1C10	Tantalum, 47 mfd ± 20%, 35 v d-c w. Sprague Type #167D476X0035S2. GE Drawing C-7781529-P19.	Aluminum, electrolytic; 50 mfd +100% -10%, 25 v d-c w. Matsushita Electric Part #ECE-A-25v-50. GE Drawing C-7781881-P4.
1C12	Tantalum; 10 mfd ± 20%, 35 v d-c w. Sprague Type #167D106X0035R2. GE Drawing C-7781529-P23.	Tantalum; 10 mfd± 20%, 35 v d-c w. GE Drawing C-7782371-P29
1C13	Tantalum; 47 mfd ± 20%, 20 v d-c w. Sprague Type #167D476X0020R2. GE Drawing C-7781529-P15.	Tantalum; 47 mfd ± 20%, 20 v d-c w. GE Drawing C-7782371-P28.
1C14	Tantalum; 33 mfd ± 20%, 20 v d-c w. Sprague Type #167D336X0020R2. GE Drawing C-7781529-P24.	Tantalum; 33 mfd ± 20%, 20 v d-c w. GE Drawing C-7782371-P30.
1C16	Tantalum; 47 mfd ± 20%, 20 v d-c w. Sprague Type #167D476X0020R2. GE Drawing C-7781529-P15.	Tantalum; 47 mfd ± 20%, 20 v d-c w. GE Drawing C-7782371-P28.
1C24	Tantalum; 47 mfd ± 20%, 20 v d-c w. Sprague Type #167D476X0020R2. GE Drawing C-7781529-P15.	Tantalum; 47 mfd ± 20%, 20 v d-c w. GE Drawing C-7782371-P28.

INTRODUCTION

The PL-7673939G1 Sync Generator Module is designed to provide synchronized horizontal and vertical drive pulses for positive (2:1) interlace operation of the G-E Types TE-20-A and TE-22-A CCTV (closed circuit television) Cameras in a variety of commercial, industrial, or military applications where a system sync is not required. It may also be used, along with a Type PX-72-A Remote Sync Adapter, as a sync generator for the TE-9 Series Cameras, in place of the Sync Board, PL-7493274G2.

The PL-7673939G1 Sync Generator Module includes the Sync Board, PL-7673917G1, along with mounting hardware and shields, as described below.

EQUIPMENT

This listing shows how the material is applied to either the TE-20-A and TE-22-A or the TE-9 Series Cameras. The part numbers listed are the same as those on PL-7673939 and on the drawings. See Fig. 1.

Part No. (PL-7673939 and Fig. 1)		TE-20-A TE-22-A	TE-9 Series
1	Assembly	— See Fig. 1 —	
2	Sync Board, PL-7673917G1	1	1
3	*Remote Sync Adapter, Model 4PX72A1	-	1*
4	Insulator, Textolite	1	1
5	Shield, copper	1	1
6	**Strap, brass	2	2
7	**Clip, phosphor, bronze	2	(Not used)
8	**Screw, #4-40 x 3/16"	2	(Not used)
9	**Wire, #24 AWG, white/black, 10"	(Not used)	1
10	**Terminal lug, tinned copper	(Not used)	1
11	**Screw, #4-40 x $\frac{1}{4}$"	4	4
12	**Lockwasher, #4 (internal tooth)	4	4
13) 14) 15)	Camera Interconnection Diagram	See Camera Instruction Book	See Fig. 2
16	**Bag, cloth	1	1
17	Upper shield, copper	1	1

*Model 4PX72A1 Remote Sync Adapter ordered separately for TE-9 Cameras.

**For field installation, parts 6 through 12 are packed in cloth bag, part 16.

TECHNICAL SUMMARY

Electrical

INPUTS

Voltages required from Camera for operation:

-21.5 volts
-20 volts
+18 volts
22 volts a-c, 60 cycles per second, reference.

OUTPUTS

Horizontal Pulse: 15,750 cps, 5.0 volts peak-to-peak, 4.2 microseconds, in Camera, Model 4TE20A1 or 4TE22A1; 5.5 volts peak-to-peak, 4.8 microseconds, unloaded.

Vertical Pulse: 60 cps, 2.8 volts peak-to-peak, 1100 microseconds, in Camera, Model 4TE20A1 or 4TE22A1; 4.3 volts peak-to-peak, 1100 microseconds, unloaded.

6300-Cycle Trigger for TE-9 Series Converter: 6300 cps, 5.5 volts peak-to-peak, 4.0 microseconds, unloaded.

AFC - LINE LOCK

Pull-in Range: ± 5%.
Hold-in Range: ± 10%

POWER CONSUMPTION

0.3 watt.

Operating Conditions

-20 C (-4 F) to +70 C (+158 F).

Transistor Complement

7 Type 2N396 (1Q1, 1Q2, 1Q3, 1Q4, 1Q5, 1Q6, 1Q9)
4 Type 2N526 (1Q8, 1Q10, 1Q11, 1Q13)
1 Type 2N3638 (1Q7)
1 Type 2N1304 (1Q12)

DESCRIPTION

The Sync Board, PL-7673917G1, is a small circuit board with four captive mounting screws, designed to be mounted in the top of the Camera frame of the G-E Type TE-20-A, TE-22-A, and TE-9 Series Cameras. The Board has printed conductors on both top and bottom, with all components and marking on the top only. The Sync Generator Module, PL-7673939G1, includes the Sync Board and all shields and hardware required for installation in the Camera. (See the EQUIPMENT section, above, and Fig. 1). For TE-9 Series Cameras, a Model 4PX72A1 Remote Sync Adapter must be ordered separately to complete the installation.

The Sync Board circuit consists of a 31.5 kc master oscillator (M.O.) and five frequency dividers to yield 60-cycle vertical and 15.75 kc horizontal trigger pulses, which are locked to the M.O. The frequency dividers are 2:1 for the 15.75 kc rate and 5,7, 5, and 3:1 for the 60-cycle rate. All frequency dividers are blocking oscillators with RC timing networks in their emitter circuits. The vertical drive output consists of a multivibrator which is started by the 60-cycle trigger and turned off by a 900-cycle trigger in the divider chain. This produces a pulse which is 17 lines wide.

The AFC circuit uses a phase comparison circuit to develop a correction voltage that controls the M.O. frequency. This circuit compares the 60-cycle output of the dividers with the 60-cycle line frequency to lock the scanning system pulses to the power line frequency. The AFC circuit can be disabled by moving a jumper; the M.O. then becomes free running.

When used with the TE-9 Series Cameras, a pulse at 6300 cps is taken from the first 5:1 counter and fed to the Power Supply/Sweep Board to trigger the converter through a buffer. The converter counts down 6:1 again and operates finally at 1050 cps in synchronism with the counter chain.

INSTALLATION

NOTE

The Sync Board is usually installed in the Camera and completely tested and adjusted before shipment. This section is provided mainly as a maintenance aid, and to meet the demands of an occasional field installation of the Sync Board.

Before starting the installation,

familiarize yourself with the parts of the kit listed in the EQUIPMENT section (above) and with the Installation Drawing, Fig. 1.

CAUTION

Disconnect Camera power before removing its cover.

The Camera cover is removed by loosening the two screws at the rear and sliding it off the rear of the Camera. Drilling is provided at the top of the Camera frame for mounting the Sync Board. Except for the single wire which must be added for the TE-9 Series Cameras (see below) all interconnections are made by the wires in the Sync Board pigtail. The Sync Board is mounted in the top rail, toward the front of the Camera, as described below in separate sections for the TE-20-A, TE-22-A, and the TE-9 Series Cameras.

TE-20-A and TE-22-A Cameras

1. Remove the aluminum light shield from between the top of the rails.
2. Place the lower shield (part 5) on the rail with the grounding foot forward and up and align it with the drilling at the front of the Camera. Cover with the insulator board (part 4) and align with drilling.
3. Using #4-40 x $\frac{1}{4}$ screws (part 11) and lockwashers (part 12), fasten brass straps (part 6) under the pigtail end of the Sync Board, as shown in Fig. 1.
4. Align the Board with the drilling and fasten with the four captive screws. Using the two #4-40 x 3/16 screws (part 8) and two clips (part 7) fasten the rear of the Board to the rail.
5. Feed the pigtail down through the hole in the frame in front of the rear plate and out the right side so that connections may be made to the Power Supply/Sweep Board keystone terminals as described in the Camera instruction book. Also see Fig. 14, the Camera Schematic Diagram, in the Camera book.

For convenience, the interconnections are tabulated here.

Sync Board Terminal	Power Supply/Sweep Board Terminal
1	17
2	1
3	21
4	23
5	18
6	13

The connection is made by sliding the tinned end of the wire through the eye into the clip portion of the terminal.

CAUTION

If, for any reason, one of these wires needs to be disconnected, lightly spring open the terminal clip with a solder aid or a small screwdriver when removing the wire to avoid the possibility of breakage.

5. After the Board is secured and wiring complete, clip the top shield (part 17) over the rails, with the fingers forward and contacting the front plate.

When replacing the cover, slide it slowly forward, making certain that the cover clears the components and shield and that it seats properly.

TE-9 Series Cameras

1. Remove any boards, such as the Model 4PX72A1 Sync Adapter, or shields from the top rail.

NOTE

The Model 4PX72A1 Remote Sync Adapter used for this installation must be a late production version with the two 0.140" diameter holes drilled to accommodate the two #4-40 screws (part 11) shown in Fig. 1 (step 7).

2. Place the lower shield (part 5) on the rail with the grounding foot forward and up and align it with the drilling at the front of

the Camera. Cover with the insulator board (part 4) and align with drilling.

3. Using #4-40 x $\frac{1}{4}$ screws (part 11) and lockwashers (part 12), fasten the brass straps (part 6) under the pigtail end of the Sync Board, as shown in Fig. 1.

4. Remove the sleeving from the pigtail and fan out the wires. Make the interconnections to the Model 4PX72A1 by soldering to 1J1 as shown in Fig. 2. The wires will have to be shortened about six inches to dress the interconnections to about four inches.

Using the #24 AWG wire (part 9) connect terminal #8 on the Sync Board to terminal E2 on the Remote Sync Adapter. (Terminal #8 is located on the Board, between C7 and R14.)

5. Carefully align the Sync Board, the lower shield and insulator board with the drilling in the frame and fasten with the four captive screws.

6. Connect 1P1 to 1J1 and carefully return the cable to the Camera. Fasten down the Model 4PX72A1 Sync Adapter with the two captive screws.

7. Using the remaining two #4-40 x $\frac{1}{4}$ screws (part 11) and lockwashers (part 12) fasten the Sync Adapter to the brass straps (part 6) on the Sync Board.

8. After the Board is secured and the wiring complete, clip the top shield (part 17) over the rail with fingers forward and contacting the front plate.

When replacing the cover slide it slowly forward, making certain that the cover clears the components and shield and that it seats properly.

OPERATION

The AFC jumper must be in the ON clip for 60-cycle line lock operation.

CAUTION

Lightly spring open the terminal clip with a solder aid or small screwdriver when removing the wire to avoid the possibility of breakage.

If non-line lock, 50-cycle, or battery (TE-9 Series only) operation is desired, move the jumper to the OFF clip. The jumper must be in a clip at all times - never loose.

The controls on the Sync Board are set for proper operation before shipment. Since these control settings are critical to the proper operation of the Sync Board, no routine operating adjustment should be attempted, even though the Control Functions are listed for descriptive purposes below.

If the Type TE-20-A or TE-22-A Camera does not seem to synchronize properly, 2L1 on the Power Supply/Sweep Board may require readjustment, as described in the Camera instruction book.

If it appears necessary to check the M.O. frequency or to readjust the counters, refer to the MAINTENANCE section of this book for a detailed procedure.

Control Functions

Control	Function
1R5	Sets the RC time constant in the emitter of 1Q1, and thereby sets the free-running frequency of the Sync Generator Board master oscillator to 31.5 kc.
1R12	Adjusts the division ratio of 1Q3 to 5:1.
1R17	Adjusts the division ratio of 1Q4 to 7:1.
1R22	Adjusts the division ratio of 1Q5 to 5:1.
1R27	Adjusts the division ratio of 1Q6 to 3:1.
1R53	Adjusts the sine-wave 60-cycle reference voltage to a value of 1.3 volts peak-to-

Control	Function
	peak as it appears across 1C16 on an oscilloscope.
AFC ON-OFF Jumper	In the ON position, the AFC circuit is connected to the AFC clamp reference voltage and supplies an error correcting voltage to the master oscillator; in the OFF position, a fixed d-c reference voltage is applied to the Sync Board master oscillator and frequency dividers for other than 60-cycle line lock operation.

THEORY AND CIRCUIT ANALYSIS

Refer to the Sync Board Schematic Diagram, Fig. 11.

The basic circuit of the Sync Board is a stabilized blocking oscillator used in conjunction with four frequency-divider circuits. The divider circuit counts down from 31,500 cycles to 60 cycles. A 2:1 divider counts from 31,500 cycles to 15,750 cycles.

In the operation of the master oscillator, capacitors 1C2 and 1C23 charge toward the -20 volt supply voltage, and since the transformer winding of 1T1 has some resistance and there is a small voltage drop across transistor 1Q1, the capacitor voltage at 1T1 is several volts less than the -20 volt supply. When 1T1 reaches saturation, the regenerative part of the cycle ceases and 1Q1 is driven to cutoff. At this time 1C2 and 1C23 start to discharge toward ground potential through 1R3 and 1R5. When the emitter voltage is within a few tenths of a volt of the base voltage (the AFC bus at -12 volts), 1Q1 conducts through 1T1 and the cycle repeats itself.

The frequency of oscillation depends, primarily, on (1) the supply voltage (-20 volts), (2) the threshold voltage (-12 volts AFC bus), and (3) the time constant 1R3 and 1R5 - 1C2 and 1C23. The supply voltage is well regulated and can be considered constant. The AFC voltage is normally at -12 volts d-c. If the power line frequency differs from the 60-cycle vertical output pulse frequency, the AFC voltage swings plus or minus up to several tenths of a volt from the nominal -12 volts. The purpose of this voltage swing is to control the frequency of the master oscillator, and to some extent the frequency of the divider chain, in order to obtain a wide pull-in and hold-in AFC range.

In the frequency dividers, if a positive-going trigger pulse of sufficient amplitude is inserted into the emitter circuit of 1Q3, 1Q4, 1Q5, or 1Q6, the blocking oscillator circuit produces oscillations of such frequency that they are an exact submultiple of the trigger pulse frequency. The emitter resistor, 1R12, 1R17, 1R22, or 1R27, is variable so that the free-running frequency can be made slightly lower than the desired triggering frequency (refer to the MAINTENANCE section). The diode and resistor (1CR10 and 1R13, typical), together, form a one-way path for the trigger pulses, thus permitting a minimum amount of back loading on the previous oscillator.

The master oscillator stage, 1Q1, is isolated from the 525:1 divider chain by the buffer stage, 1Q2, which provides a trigger pulse for the 2:1 divider stage, 1Q9. 1Q7 and 1Q8 form a monostable multivibrator and generate the vertical drive pulse which is initiated by the 60-cycle trigger pulse from divider stage 1Q6. A trigger pulse from the output of 1Q4 stops the multivibrator, thus maintaining the vertical drive pulse at a constant width of 17 lines (see Fig. 3). 1CR11 and 1CR13 serve to clip the trigger pulses into 1Q7.

1Q10, 1Q11, 1Q12, and 1Q13 make up the AFC circuit. The vertical drive pulse is compared (in time) to the 60-cycle power line frequency. Refer to Fig. 4. If the vertical drive pulse should arrive at the same time the wave is crossing its zero axis, a zero error output voltage results. If the vertical drive pulse arrives on either side of the axis, capacitor 1C14 charges toward

this new voltage. This error voltage, if any, causes the master oscillator to speed up or slow down (depending on the polarity of the error voltage) to keep the Sync Board locked to the power line frequency (60 cycles). Capacitor 1C14 must charge at a moderate rate in order to follow the changes in the power line frequency. The capacitor must not discharge between the 60-cycle vertical drive pulse in order to prevent phase modulation of the master oscillator. Phase modulation of the master oscillatqr would cause the sides of the blanked raster to be uneven when viewed on an AFC type monitor. Therefore, capacitor 1C14 has two cascaded emitter followers that act as a buffer to provide a high impedance across capacitor 1C14. When the AFC jumper is in the OFF position, the master oscillator frequency is not corrected but is fixed by a d-c potential derived from the voltage divider, 1R43-1R44. AFC-OFF is used only when the Camera is operated on a d-c power or a-c other than 60 cycles.

MAINTENANCE

General

To assure continuous satisfactory operation of the Sync Board, keep it as clean and dry as possible. Always leave the cover on the Camera for best protection. Take care not to disturb the position of components and wiring, and see that shields are left properly installed (Fig. 1).

Parts Replacement

The Parts List for the Sync Board is located in the back of this book. See Fig. 10 for the placement of parts.

If a component requires replacement, obtain its description from the Parts List and the part from a local parts distributor. In cases where a special part not available from a distributor must be replaced, order it by G-E Drawing Number (found in the Parts List), addressing the order to the General Electric Company, Replacement Parts, Visual Communications Products Business Section, Electronics Park, Syracuse, N. Y.

Trouble Shooting

The first step in locating trouble is to isolate it to a particular section of the Sync Board. Socket voltages are included on the Schematic Diagram and are useful in point-to-point checking. Typical Sync Board waveforms are shown in Figs. 5 and 6.

If the picture will not lock horizontally, check the INSTALLATION and OPERATION sections of this book to see that all requirements are met.

Component Board Service Notes

Although the Sync Board is designed to be extremely rugged when mounted as an integral part of the Camera, extreme care must be used in handling it when alone. Parts may be damaged, for example, by placing the Board component-side down and inadvertently placing another object on it.

The following steps will be of aid when replacing components on the Board. Use only a 25- or 35-watt soldering iron as excessive heat can damage wiring and components.

CAUTION

DO NOT USE A LARGE SOLDERING IRON TO SERVICE THE BOARD.

DO NOT REMOVE A TRANSISTOR FROM ITS MOUNTING FACILITY WHILE POWER IS APPLIED TO THE BOARD; TO DO SO MAY PERMANENTLY DAMAGE THE TRANSISTOR.

1. Grip the component to be removed at one end with long-nose pliers, then apply a narrow-tip soldering iron to the component lead, barely touching the Board wiring. While the solder joint melts, lightly pull with the

pliers until the lead can be pulled free of the Board. Free the other lead in the same manner.

2. When a component is removed, it should be replaced with a new component of the same value. When installing the new component, observe the length and dress of the leads on the old component, then cut and bend the leads of the new component in the same way.

3. Place the leads in the holes. If residual solder prevents a lead from entering the hole, very gently ream out the solder with a sharply pointed, square awl. Then place the leads in the holes so that the component is held in place by friction or slight spring tension of the leads.

4. Using high grade electrical solder, apply the soldering iron tip, then apply the solder to the junction of the hole, so that a very small amount of solder flows around the lead and into the hole, bonding the lead to the Board.

5. Examine the joint carefully. A good solder joint should withstand a light pull by the fingers. Clear away any loose solder, making sure that no scraps fall where they might cause a short.

To insure proper Camera operation, the Board must be properly reinstalled in the Camera; follow the INSTALLATION instructions. When replacing the Camera cover, slide it slowly forward, making certain that the cover clears the components and shield and that it seats properly.

Trouble-Shooting Transistor Circuits

The trouble-shooting techniques described in EBI-3781 (see the Camera Instruction Book) are applicable to the Sync Board.

Sync Generator Adjustment

MASTER OSCILLATOR

1. Apply power to the Camera with the cover removed. Turn the BEAM control fully counterclockwise. Allow a five-minute warm-up. Place the AFC jumper in the OFF position.

CAUTION

Lightly spring open the terminal clip with a solder aid or small screwdriver when removing the wire to avoid the possibility of breakage.

2. Using a frequency counter connected between ground and the collector of 1Q2, adjust 1R5 to give a frequency count of 31,500 cycles per second.

3. If a counter is not available, an oscilloscope may be used to compare the M.O. frequency with an external source of 15,750 cycles or 31,500 cycles. Feed the signal from the collector of 1Q2 into the Y deflection input and the external standard signal into the X deflection input. When the external source is 15,750 cycles, a Lissajous pattern of two loops appears when the M.O. frequency is correct. When the external source is 31,500 cycles, a Lissajous pattern of one loop is correct.

CAUTION

Adjust the oscilloscope for at least two complete sawteeth in the procedure below. Make certain that the correct count appears on both.

COUNTERS

1. With the M.O. at the correct frequency, observe the signal at the 5:1 test point (emitter of 1Q3) on the 'scope. Adjust 1R12 for a sawtooth with five spaces between trigger pulses as shown in Fig. 7. Center the potentiometer adjustment between the counts of 4:1 and 6:1.

2. Observe the signal at the 7:1 test point (emitter of 1Q4) on the 'scope. Adjust 1R17 for a sawtooth with seven spaces between the trigger pulses as shown in Fig. 8. Center the potentiometer adjustment between the counts of 6:1 and 8:1.

3. Observe the signal at the 5:1 test point (emitter of 1Q5) on the 'scope. Adjust 1R22 for a sawtooth with five spaces between the trigger pulses as shown in Fig. 7. Center the potentiometer adjustment between the counts of 4:1 and 6:1.

4. Observe the signal at the 3:1 test point (emitter of 1Q6) on the 'scope. Adjust 1R27 for a sawtooth with three spaces between trigger pulses as shown in Fig. 9. Center the potentiometer adjustment between the counts of 2:1 and 4:1.

PARTS LIST

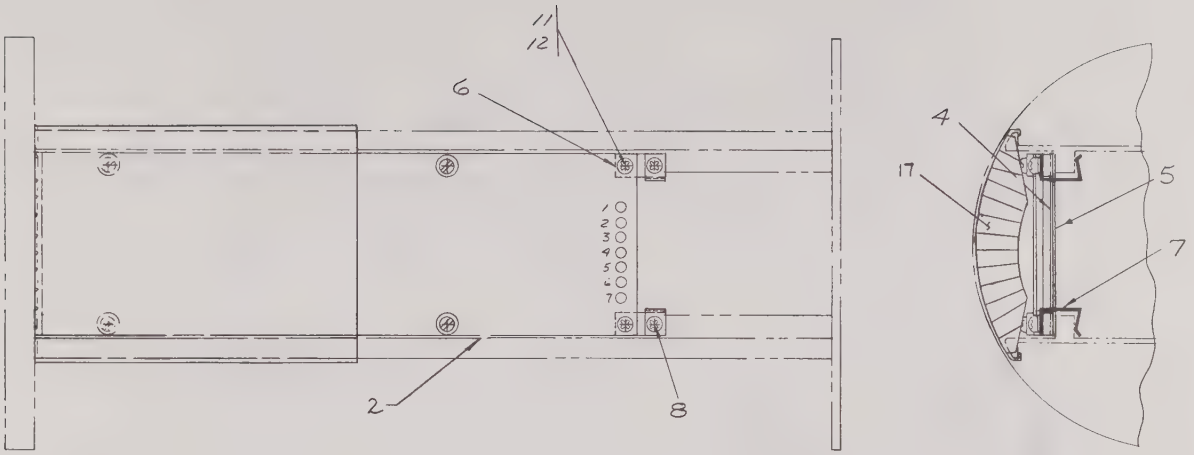
Symbol	Description	GE Drawing
	SYNC BOARD PL-7673917G1	
	CAPACITORS (Tantalum type, ± 20%, 50 v d-c w, unless otherwise specified)	
1C1	10 mfd, 35 v d-c w.	C-7782371-P29
1C2	Silver mica, epoxy dipped; 4700 mmfd ± 5%, 300 v d-c w. Electromotive Type DM15.	B-7496932-P24
1C4 and 1C5	4.7 mfd. Kemet Type J.	C-7781529-P21
1C6	Mylar, dielectric; 0.047 mfd ± 5%, 50 v d-c w.	B-7496934-P204
1C7	Mylar, dielectric; 0.1 mfd ± 5%, 50 v d-c w.	B-7496934-P206
1C8 and 1C9	Mylar, dielectric; 0.33 mfd ± 5%, 50 v d-c w.	B-7496934-P209
1C10	Aluminum, electrolytic; 50 mfd +100% -10%, 25 v d-c w. Matsushita Electric Part #ECE-A-25v-50.	C-7781881-P4
1C11	4.7 mfd. Kemet Type J.	C-7781529-P21
1C12	10 mfd, 35 v d-c w.	C-7782371-P29
1C13	47 mfd, 20 v d-c w.	C-7782371-P28
1C14	33 mfd, 20 v d-c w.	C-7782371-P30
1C16	47 mfd, 20 v d-c w.	C-7782371-P28
1C17	4.7 mfd. Kemet Type J.	C-7781529-P21
1C18	Mylar, dielectric; 0.01 mfd ± 20%, 50 v d-c w.	B-7496934-P1

Symbol	Description	GE Drawing
	CAPACITORS (CONTINUED) (Tantalum type, ± 20%, 50 v d-c w, unless otherwise specified.)	
1C19	Mylar, dielectric; 0.022 mfd ± 5%, 50 v d-c w.	B-7496934-P202
1C20	4.7 mfd. Kemet Type J.	C-7781529-P21
1C22	4.7 mfd. Kemet Type J.	C-7781529-P21
1C23	Silver mica, epoxy dipped; 4700 mmfd ± 5%, 300 v d-c w. Electromotive Type DM15.	B-7496932-P24
1C24	47 mfd, 20 v d-c w.	C-7782371-P28
1C25	Mylar, dielectric; 0.15 mfd ± 20%, 50 v d-c w.	B-7496934-P7
	RECTIFIERS	
1CR1	Sylvania Electric Type 1N663.	A-7164424-P49
1CR2	Hughes Type HD2152 or Type 1N279.	A-7164424-P29
1CR3	Germanium diode; 80 PIV max. Hughes Type HD2151.	C-7777146-P12
1CR4	Hughes Type HD2152 or Type 1N279.	A-7164424-P29
1CR6	Germanium diode; 80 PIV max. Hughes Type HD2151.	C-7777146-P12
1CR7	Hughes Type HD2152 or Type 1N279.	A-7164424-P29
1CR8	Germanium diode; 80 PIV max. Hughes Type HD2151.	C-7777146-P12
1CR9 and 1CR10	Hughes Type HD2152 or Type 1N279.	A-7164424-P29
1CR11	Germanium diode; 80 PIV max. Hughes Type HD2151.	C-7777146-P12
1CR12	Hughes Type HD2152 or Type 1N279.	A-7164424-P29

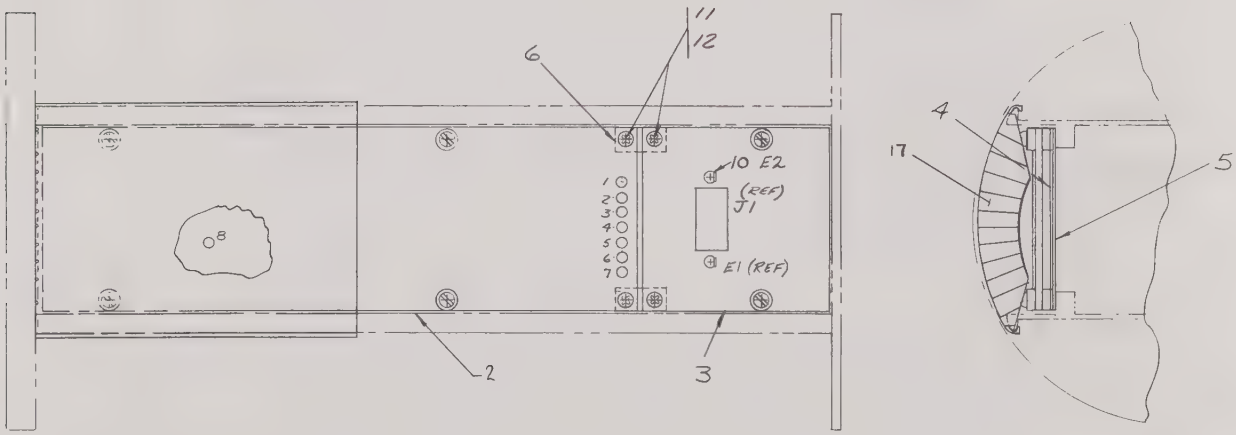
Symbol	Description	GE Drawing
	RESISTORS (Composition, ± 5%, ¼ w, unless otherwise specified)	
1R1	10,000 ohms.	C-3R152-P103J
1R2	470 ohms.	C-3R152-P471J
1R3	Precision, metal film; 11,000 ohms ± 1%, ½ w. Weston Type 9855-2-B.	B-7494168-P1
1R4	1000 ohms.	C-3R152-P102J
1R5	Potentiometer, wirewound; 2000 ohms ± 5%, resolution 0.27%. IRC Model #100 Circitrim.	B-7496557-P6
1R6	1000 ohms.	C-3R152-P102J
1R7	5100 ohms.	C-3R152-P512J
1R8	680 ohms.	C-3R152-P681J
1R9	220 ohms.	C-3R152-P221J
1R10	1000 ohms.	C-3R152-P102J
1R11	Precision, carbon film; 10,000 ohms ± 1%, 1/8 w. Mepco Type C-5.	B-7493394-P4
1R12	Potentiometer, composition; 5000 ohms ± 20%, 0.4 w, linear taper. Allen Bradley Type O.	B-7493391-P3
1R13	330 ohms.	C-3R152-P331J
1R14	3300 ohms.	C-3R152-P332J
1R15	6800 ohms.	C-3R152-P682J
1R16	Precision, carbon film; 39,000 ohms ± 1%, 1/8 w. Mepco Type C-5.	B-7493394-P8
1R17	Potentiometer, composition; 10,000 ohms ± 20%, 0.4 w, linear taper. Allen Bradley Type O.	B-7493391-P4
1R18	330 ohms.	C-3R152-P331J
1R19	1800 ohms.	C-3R152-P182J
1R21	Precision, carbon film; 51,000 ohms ± 1%, 1/8 w. Mepco Type C-5.	B-7493394-P17

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, ¼ w, unless otherwise specified.)	
1R22	Potentiometer, composition; 25,000 ohms ± 20%, 0.4 w, linear taper. Allen Bradley Type O.	B-7493391-P5
1R23	330 ohms.	C-3R152-P331J
1R24	1300 ohms.	C-3R152-P132J
1R26	Precision, carbon film; 180,000 ohms ± 1%, 1/8 w. Mepco Type C-5.	B-7493394-P9
1R27	Potentiometer, composition; 100,000 ohms ± 20%, 0.4 w, linear taper. Allen Bradley Type O.	B-7493391-P8
1R28	330 ohms.	C-3R152-P331J
1R29	470 ohms.	C-3R152-P471J
1R31	470 ohms.	C-3R152-P471J
1R33	4700 ohms.	C-3R152-P472J
1R34	4700 ohms.	C-3R152-P472J
1R36	470 ohms.	C-3R152-P471J
1R37	820 ohms.	C-3R152-P821J
1R38	22,000 ohms.	C-3R152-P223J
1R39	1000 ohms.	C-3R152-P102J
1R41	2000 ohms.	C-3R152-P202J
1R42	4700 ohms.	C-3R152-P472J
1R43	Precision, carbon film; 2200 ohms ± 1%, 1/8 w. Mepco Type C-5.	B-7493394-P10
1R44	Precision, carbon film; 3300 ohms ± 1%, 1/8 w. Mepco Type C-5.	B-7493394-P14
1R46	15,000 ohms.	C-3R152-P153J
1R48	Precision, carbon film; 2200 ohms ± 1%, 1/8 w. Mepco Type C-5.	B-7493394-P10

Symbol	Description	GE Drawing
	RESISTORS (CONTINUED) (Composition, ± 5%, $\frac{1}{4}$ w, unless otherwise specified)	
1R49	Precision, carbon film; 3300 ohms ± 1%, 1/8 w. Mepco Type C-5.	B-7493394-P14
1R51	22,000 ohms.	C-3R152-P223J
1R52	1800 ohms.	C-3R152-P182J
1R53	Potentiometer, composition; 5000 ohms ± 20%, 0.4 w, linear taper. Allen Bradley Type O.	B-7493391-P3
1R54	12,000 ohms.	C-3R152-P123J
1R55	470 ohms.	C-3R152-P471J
1R56	6800 ohms.	C-3R152-P682J
1R57	470 ohms.	C-3R152-P471J
1R58	Precision, carbon film; 12,000 ohms ± 1%, 1/8 w. Mepco Type C-5.	B-7493394-P18
1R59	To be selected in test.	
1R65	220 ohms.	C-3R152-P221J
1R66	470 ohms.	C-3R152-P471J
	TRANSFORMERS	
1T1	Pulse transformer. Pri d-c resistance: 12.2 ohms; sec #1 d-c resistance: 13.0 ohms; sec #2 d-c resistance: 14.2 ohms.	B-7493382-P1
1T2 thru 1T6	Pulse transformers. Pri d-c resistance: 21 ohms; sec #1 d-c resistance: 23 ohms; sec #2 d-c resistance: 25 ohms.	B-7493381-P1
	TRANSISTOR SOCKETS	
1XQ1 thru 1XQ13	Elco Cat. #3305.	B-7495897-P2



INSTALLATION OF SYNC GENERATOR IN 4TE20 & 4TE22 CAMERAS.



INSTALLATION OF SYNC GENERATOR & REMOTE SYNC ADAPTER IN 4TE9 CAMERAS.

Fig. 1 Installation Drawing, Sync Generator Module in TE-20-A and TE-22-A or TE-9 Series Cameras (D-7673939, Rev. A)

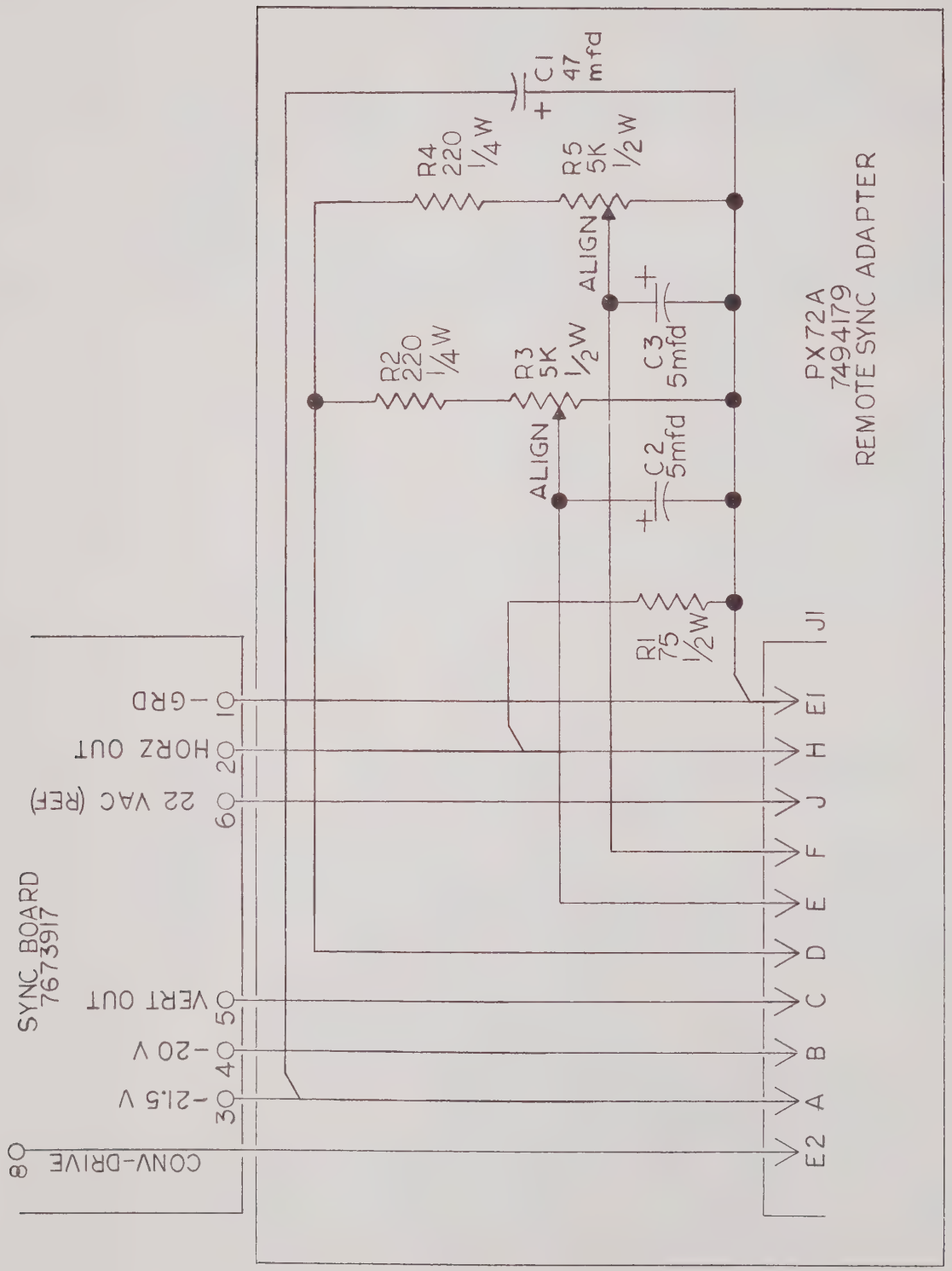


Fig. 2 TE-9 Series Interconnection Diagram, Sync Board to PX-72-A Sync Adapter (B-7497214, Rev. B)

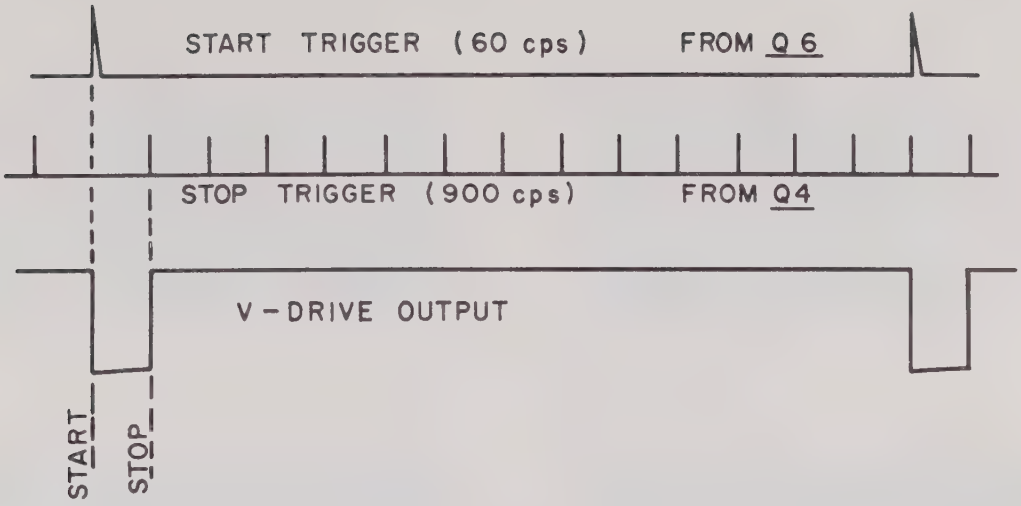


Fig. 3 V Drive Pulse Width Output Waveforms

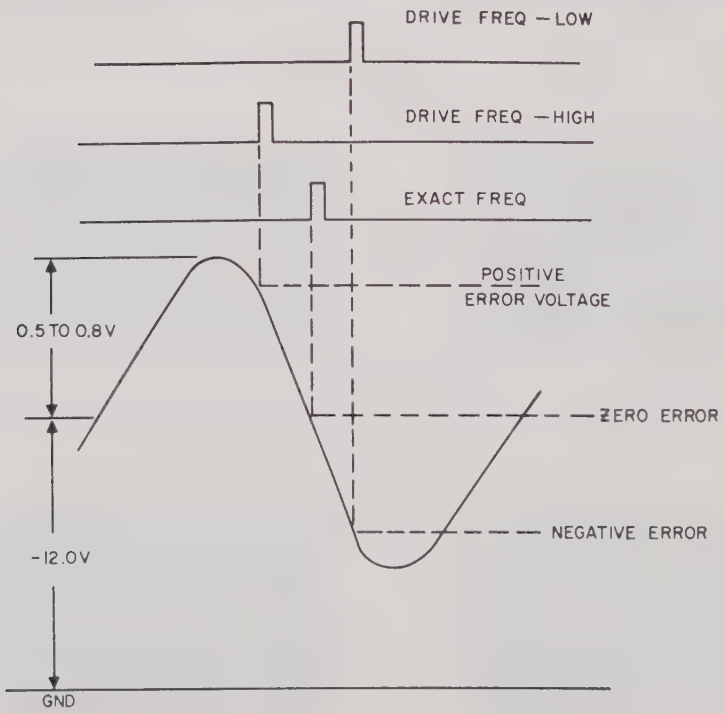
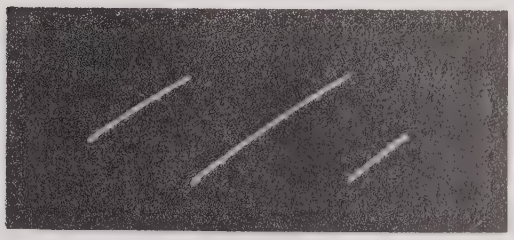


Fig. 4 Comparison, V Drive Pulse to 60-Cycle Power Line Frequency Waveform

(a) 1Q1 Emitter, 31.5 kc Sawtooth, 3.4 volts P-P

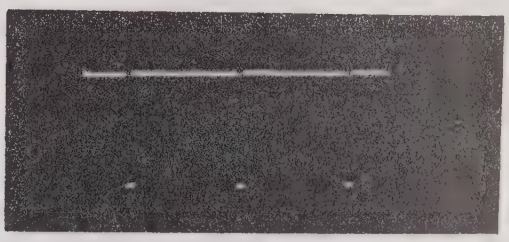
(b) 1Q3 Emitter, 5/1 count, 3.6 volts P-P

(c) 1Q4 Emitter, 7/1 count, 3.6 volts P-P

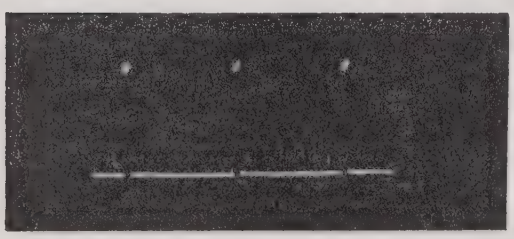


(d) 1Q5 Emitter, 5/1 count, 3.6 volts P-P

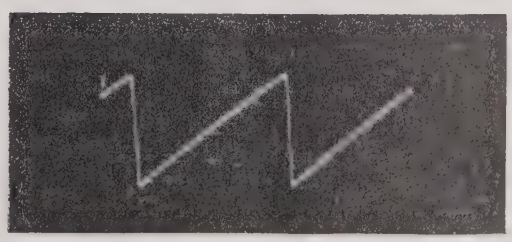
(e) 1Q6 Emitter, 3/1 count, 3.6 volts P-P



(f) 1Q7 Base, V Multivibrator, 4 volts P-P



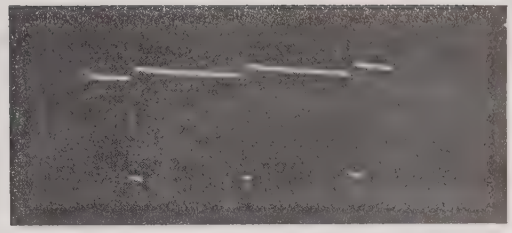
(g) 1Q7 Collector, V Multivibrator, 18 volts P-P



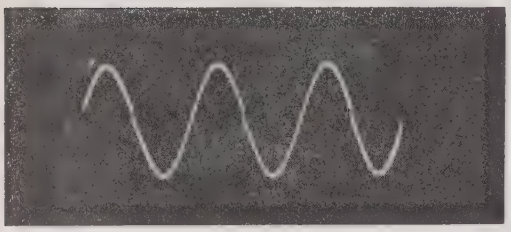
(h) 1Q9 Emitter, 2/1 count, H rate, 3.2 volts P-P

Fig. 5 Sync Board Waveforms (a-h)

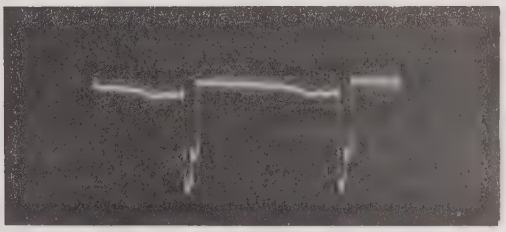
(i) 1Q9 Base, 31.5 kc, H drive, 5 volts P-P



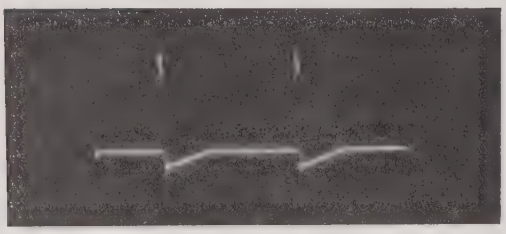
(j) 1Q10 and 1Q11 Base, AFC Clamp, 3.1 volts P-P



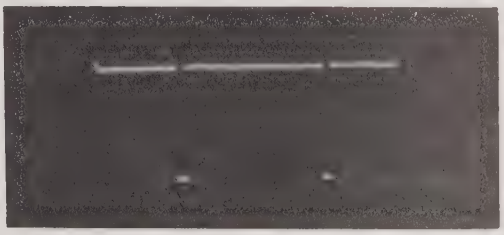
(k) 1Q11 Emitter, Clamp, 1.3 volts P-P



(l) Horizontal Out, 4.6 volts P-P Horizontal Pulse



(m) Horizontal Trigger Pulse Out, 8 volts P-P



(n) Vertical Pulse Out, 3.1 volts P-P

Fig. 6 Sync Board Waveforms (i-n)

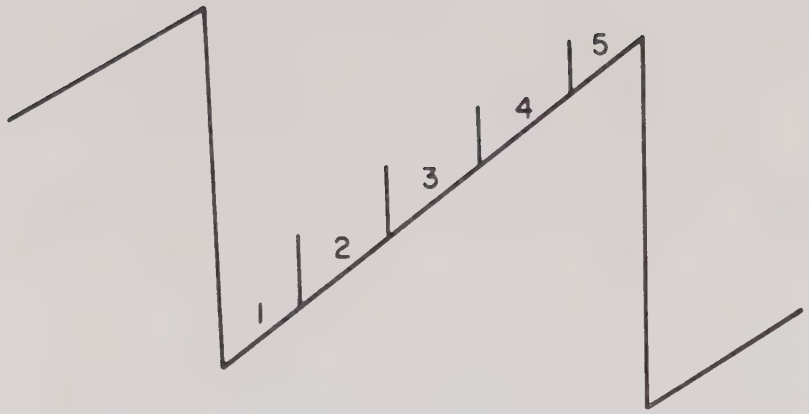


Fig. 7 5:1 Counter Sawtooth

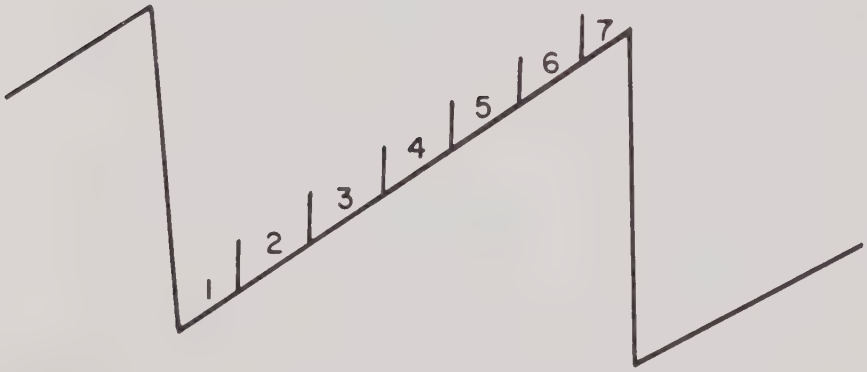


Fig. 8 7:1 Counter Sawtooth

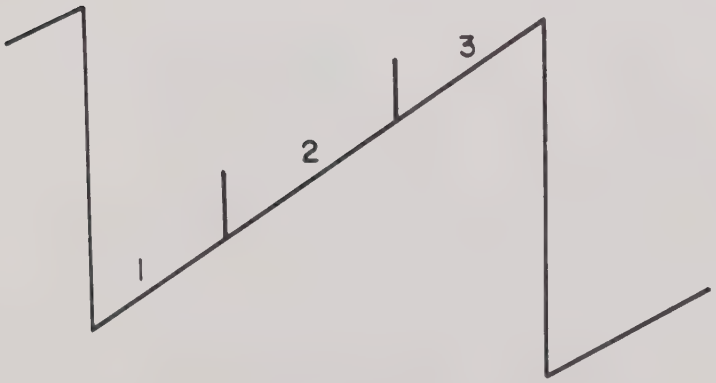
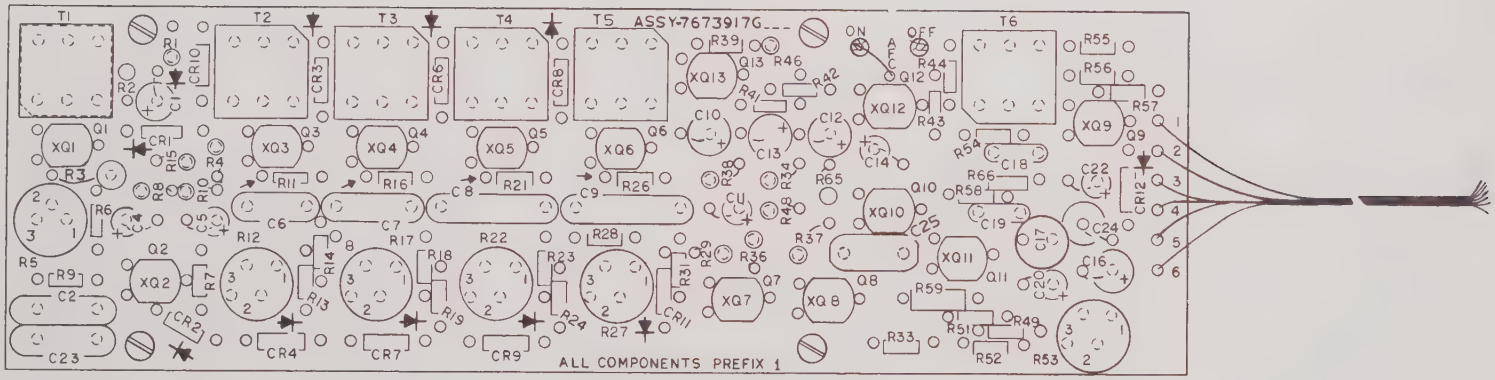


Fig. 9 3:1 Counter Sawtooth



→ DENOTES COUNTER TEST POINTS.

Fig. 10 Component Layout Drawing, Sync Board, PL-7673917G1 (D-7673917, Sheet 1, Rev. D)

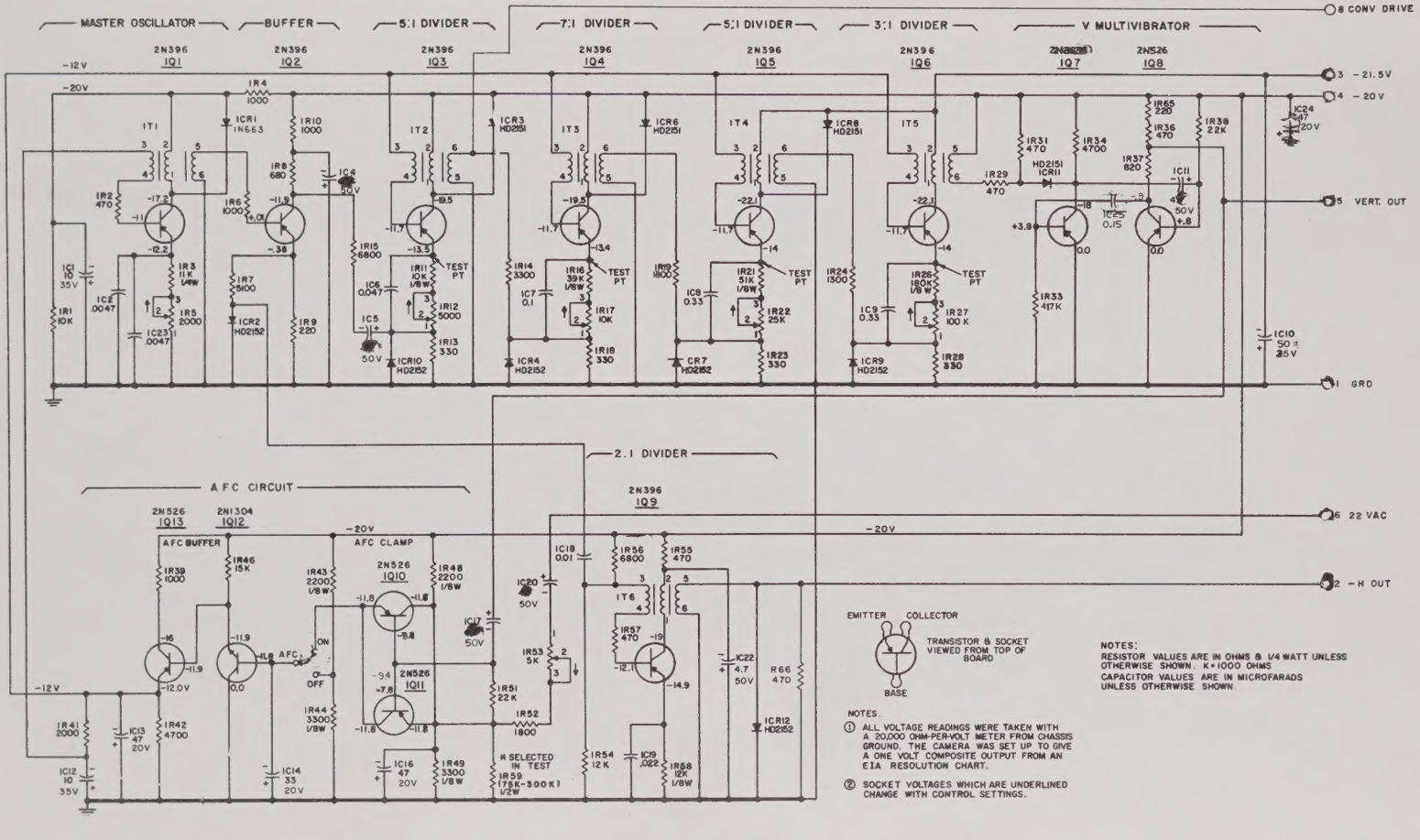

MASTER OSCILLATOR
BUFFER
5:1 DIVIDER
7:1 DIVIDER
5:1 DIVIDER
3:1 DIVIDER
V MULTIVIBRATOR
2.1 DIVIDER
AFC CIRCUIT
AFC BUFFER
AFC CLAMP
8 CONV DRIVE
3 -21.5V
4 -20V
5 VERT. OUT
1 GRD
6 22 VAC
2 -H OUT
EMITTER
COLLECTOR
BASE
TRANSISTOR & SOCKET VIEWED FROM TOP OF BOARD
NOTES:
RESISTOR VALUES ARE IN OHMS & 1/4 WATT UNLESS OTHERWISE SHOWN. K=1000 OHMS
CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE SHOWN.
NOTES.
① ALL VOLTAGE READINGS WERE TAKEN WITH A 20,000 OHM-PER-VOLT METER FROM CHASSIS GROUND. THE CAMERA WAS SET UP TO GIVE A ONE VOLT COMPOSITE OUTPUT FROM AN EIA RESOLUTION CHART.
② SOCKET VOLTAGES WHICH ARE UNDERLINED CHANGE WITH CONTROL SETTINGS.
* SELECTED IN TEST

Fig. 11 Schematic Diagram, Sync Board, PL-7673917G1 (D-7673917, Sheet 2, Rev. F)

Made in U.S.A. by
BEAVERITE
BEAVER FALLS, N.Y.
8C1-219

MP MASTER
MA32573